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Programmed Learning in the Schools

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Programmed Learning in the Schools

JOHN LEEDHAM M.ED.
Researcher in Programmed Learning
University of Leicester

DERICK UNWIN, M.A.
Senior Lecturer in Programmed Learning
at Bulmershe College of Education, Reading

S.C.E.R.T., West Bengal
Library
Calcutta
25/3, B. C. Road

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Introduction

Available books about Programmed Learning tend to fall into two categories: collections of research papers, on the one hand, and theoretical treatises, on the other. Both of these can be interesting and indeed useful, but the present authors feel that neither meets the needs of the practising educator. This volume sets out to fill the gap, and its success will be measured by the extent to which it is of use to teachers, education students and others with interests in practical aspects of instruction.

Occasional reference is made in these pages to various theories of learning. The reader is warned that much of this theory is in dispute, and mention is made only for the sake of completeness. Our approach is a pragmatic one: programming works, and is a valuable teaching tool; in time to come a more concrete underlying theory may develop, but here we are concerned with practical matters based on experience.

For convenience programmes are frequently classified as either 'Linear' or 'Branching'. These terms are defined in the Glossary on pp. xiii–xvii, but it should be said here that the emphasis throughout this volume is on a generally linear approach. This is not to say that branching does not have its uses, but rather that the authors feel that competency in the field of linear programming is the prime requirement.

The glossary provided contains a detailed exposition of the more important terms used, together with a guide to programming jargon and biographical notes on prominent workers in the field.

Thereafter the book is divided as follows:

Part 1

The production and use of linear programmes for classroom use, considered in both general and specific terms.

Part 2

The use of programmed material in the primary stage, from prereading to twelve plus.

Part 3

The use of programmed material with secondary pupils, up to approximately G.C.E. 'A' Level.

Part 4

Research and the future.

GLOSSARY I

Terms in Programming

BRANCHING

A sequence of learning steps organised to provide logical progress and correction for incorrect answers. Examples and further explanation are given in Chapter 7. See also Crowder, N.

CARREL

A learning position which often resembles a booth or booths in a language laboratory where students can work undisturbed. Designed to accommodate pupils using programmes and audio-visual material either individually or in small groups.

CROWDER, N.

Developed branching or intrinsic programming which he explains in this way: 'The student is given the material to be learned in small logical units. Immediately after he has read and digested one of these units he is given a short test on it. The results of the test are used to determine what next unit of information shall be presented to the student.'

CUE (or PROMPT)

A stratagem used to focus the attention of the student and lead him to the required answer. Capitals, underlining, colour, special grammatical constructions are all used to 'cue' an answer.

FADING

This is the technique of removing 'props' through successive frames. This process is given fuller explanation in Chapter 7.

FEEDBACK

This term is used in two connections. A student, having made his response, receives feedback from the programme, i.e. he is informed as to the correctness of the response. Similarly, the programme writer obtains feedback by examining the responses made by students and can thus adapt the programme.

FORCING

This is the description given to the type of frame which compels a response. Such frames can be useful as introductory material. For example: We are learning about HEAT, LIGHT and SOUND. Having dealt with Heat and Light, we have now to learn about – – – – –. *Answer:* SOUND.

FRAME

This term has grown up with programmed learning and is meant to indicate the material presented at any one time to be learned.

INTRINSIC

This type of programming refers to the type of branching programmes developed by Norman Crowder.

GROUP CONSOLE

This is a special device which displays programmes to a group of students and advances on an assessment of group or individual response. Further explanation occurs in Chapter 9.

LINEAR PROGRAMME

This is a programme especially devised to advance the student step by step to his learning goal, and so organised that he will make minimal errors. This type of programming is more fully described in Chapters 2 and 7.

MATHETICS, MATHETICAL PROGRAMME

A system in which the required response is always the completed task. It can be likened to a process of teaching the completion of a jigsaw puzzle by presenting a child with the puzzle: (*a*) completed except for one piece; (*b*) completed except for two pieces, and so on until the full task is achieved. A useful reference is the article by Parrington and Slack in *Applied Programmed Instruction*, ed. Marguille and Eigen, Wiley, 1962.

MODES OF RESPONSE

The different ways in which responses can be made. A programme can require answers to be constructed or written (overt responding), or the answers can be thought or read (covert responding). Buttons can be pressed, apparatus manipulated or tasks performed in response to a stimulus according to the type of programme and/or machine.

OPERANT CONDITIONING

A psychological term to indicate the conditioning which results when a subject is required to *volunteer* the correct response in order to gain reinforcement.

PANELS

It is sometimes necessary for a programme to include maps, diagrams, lengthy written material, etc., which do not conveniently fit into a frame. These can be printed separately and the student referred to them at appropriate points. The term 'panel' is customarily used to describe such items.

PRESSEY, S. L.

Pressey, an Ohio State University psychologist, published pioneer studies in 1926 about his teaching machine. He presented the situation as the testing of material and a programme as a means of examining textual material.

PROMPT—*see* CUE

REINFORCEMENT

The process of confirming the progress of a student by making him aware of his *correct* behaviour as he proceeds is called reinforcement. It derives from the psychological view that rewarding an organism makes repetition of the rewarded behaviour more likely.

REVIEW ITEM

Throughout a programme it is sensible to have items which review material already presented. Examples are given in Chapter 11.

RULEG SYSTEM

One of several methods of organising a programme into sequences depending on Rules and examples. It is explained in Chapter 7.

SHAPING

A programme designed to elicit graded responses of a specific pattern can be thought of as shaping the behaviour of the responder to achieve a given aim.

SKINNER, B. F.

A Harvard psychologist, pre-eminent in the revival of programmed learning since 1957. His programmes, first developed to train his students in psychology, rely upon operant conditioning and reinforcement theory. His approach is strictly linear and makes use of very short frames. Linear programmes have often been termed Skinnerian Programmes.

SKIPPING

Students working through a linear programme can be directed to 'skip' certain frames if their programme performance warrants it. See Chapter 7.

STEP SIZE

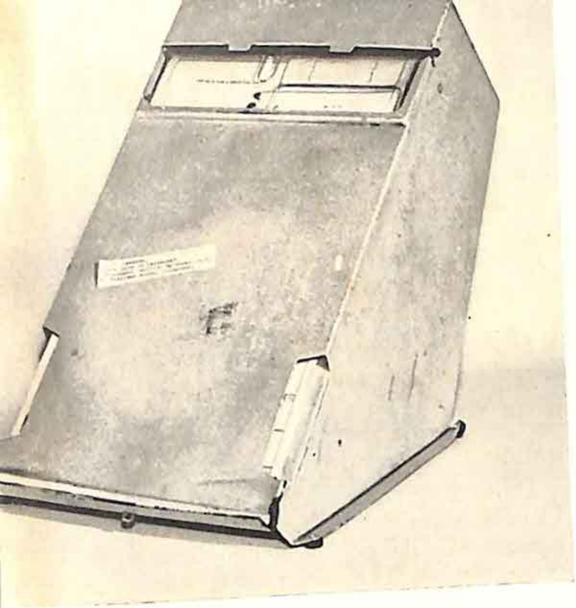
When a programme frame presents a very small advance on previous frames the step size is small. When the programme moves forward by large steps it is presenting material in frames which carry much fresh material on each occasion.

STIMULUS

Any information, request, question, order, 'prod', etc., which calls upon the student to make a response.

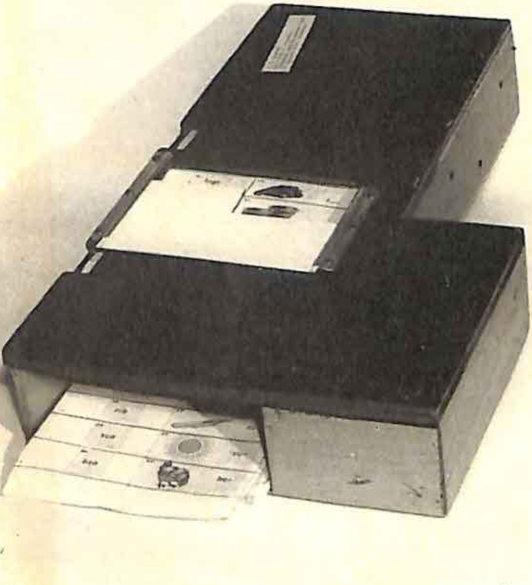
TERMINAL BEHAVIOUR

A programme usually aims to produce some type of behaviour



1. *The Min–Max Mark 1*

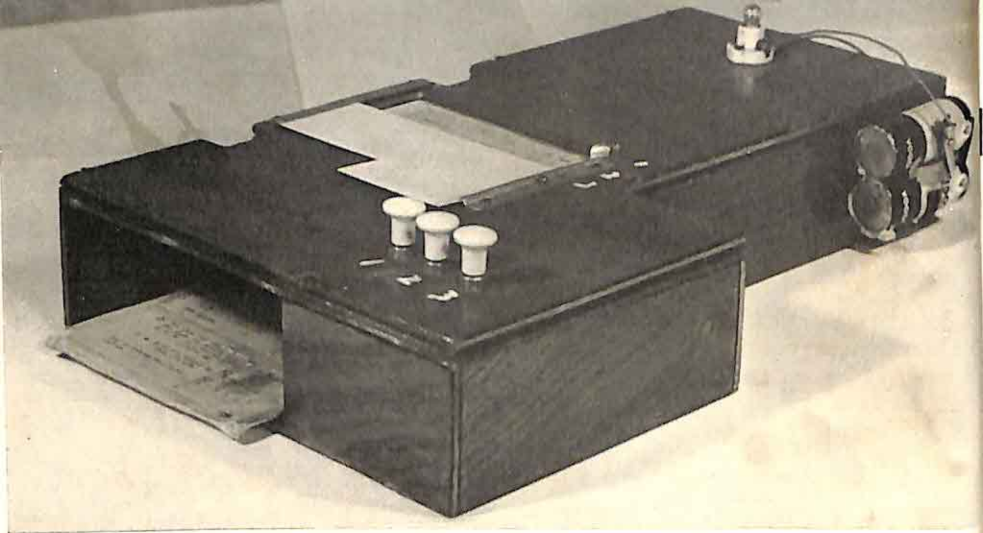
An early American linear device. The programme is presented on sheets which are advanced by finger pressure, a frame at a time. The sheet can only go one way and answers are written on the programme. Thus an answer is made in the right-hand aperture and the programme advanced one frame to see the answer. By this time the attempt is under the perspex. The programme, of course, is written on and consumed.



2. *The Probox, Mark 1*

This linear device was designed by J. F. Leedham to house and to present varieties of programmes mounted on card; it was also designed to permit of additional display area. Note the variable mask size.

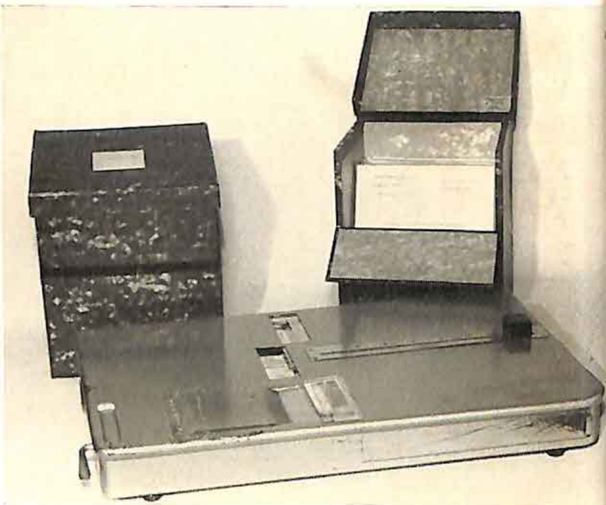
This does not incorporate an anticheat device for the answers which are written down separately. It could, therefore, be most properly regarded as a mask.



Top
3. *The Probox Mark 2*

Many adaptations of the original Probox have been attempted. Here is one where the back circuiting of the programme cards completes the circuit. Selection of the correct answer lights up the bulb.

This could be termed a 'multi-choice' answer, i.e. the programme depends upon selection of the correct answer from alternatives.



4. *The ESATutor*

This was designed to be superior in terms of robustness, loading, anticheat facility and the use of ordinary notepaper rather than rolls. In operation the machine is loaded with a pack of some twelve double-sided cards containing 130 frames.

Answer paper and programme card advance together, and both are automatically deposited.

which can be observed and which will confirm that the programme has been used successfully. The terminal behaviour could be a written test or a constructional task.

TESTS

In programming it is usual to use pre-tests which measure the attainment standard of the pupil in the subject area before he attempts the programme. A post-test examines attainment after the programme and is frequently matched with the pre-test.

VALIDATION

This refers to the testing and proving of the programmes, and the subject is covered more fully in Chapter 3.

GLOSSARY 2

Teaching Machines

These devices employ the learner actively in responding. They differ from other devices such as the film projector in that they require the student to interact with the machine. Although there is a good deal of common ground between the various types of machine, they can be classified as follows:

ADAPTIVE MACHINES

These machines react directly with the student by assessing his performance and adapting the material to his learning potential. They customarily rely upon computers and are only just emerging into practical use at this date.

NON-ADAPTIVE MACHINES

Machines which rely upon a fixed programme through which the student progresses. This programme represents the learning to be communicated.

Of the non-adaptive machines a further subdivision could be made into LINEAR and BRANCHING devices.

Linear machines. These are usually of the simplest type. They house a programme of learning which proceeds by very finely graded steps. Each programme should be so arranged and graded that the student makes very few incorrect responses. In the devices associated with Professor Skinner (*q.v.*) the answers to each 'step' or frame are immediately disclosed after the answer has been composed. Examples of these machines are those shown in Plates 1, 2, 3, 4, and 5.

Branching machines. These are designed to house programmes which do not rely upon the student getting all the answers right. The programme step or frame presents an item of information, usually of greater content than in a linear programme. On the basis of this information the student is required to answer questions which offer alternative answers, only one of which is correct. Selection of the wrong answer conveys the student to a frame where his error is explained and he is rerouted to the correct sequence. These programmes, often termed *intrinsic*, are frequently associated with the work of Crowder (*q.v.*) (see Glossary).

Each of the two branching machines shown in Plates 6 and 8 operates on the same principle. Both are relatively expensive to buy and are customarily hired at around £12 for a month. The hire of the programme, mounted on film, is extra.

PART ONE

Production and use of linear programmes

I

How programming works and how to make it work

The theoretical view

Although exaggerated claims have been made by its proponents, there is little doubt that programmed learning appears to be as effective as any other instructional method. In fact, the weaker students in a class will probably do better with a programme written at an appropriate level than with conventional instruction in large groups.

Obviously a given programme will cater for a certain range of abilities and preknowledge. If we accept that challenging programmes can be written for any level of ability, high or low, then we can prescribe the optimum situation; this will require students to be allotted programmes not according to some arbitrary class structure but rather as a result of their known ability and knowledge.

At present we do not know how wide a range of students can be efficiently catered for by one programme; a balance will always need to be drawn between efficiency and economics, between a different programme for each pupil and the same programme for each pupil. There is certainly much room for research into the needs of the individual, and into how far we can legitimately go in assigning him to groups for instruction of one sort or another. The word 'groups' is used here not in any social sense but to mean a class of individuals all receiving similar instruction.

In general, then, because programmes are administered to an over-large range of abilities, they do not realise their full potential. In spite of this handicap there is ample evidence to show that programming teaches as well as conventional instruction. How can we account for this success? What are the factors responsible for the effectiveness of programmed learning?

As a first step towards finding answers to these questions we may turn to the experimental psychologists. It is as a result of work with laboratory animals, notably by Skinner, that we have experienced the boom in teaching machines and programming of recent years. Can the successes enjoyed by programmed learning be accounted for by these workers, and may we expect from them theories of learning enabling us to maximise the efficiency of programmes?

Unfortunately, things are not quite so straightforward as this. According to Skinner's theory of linear programming, a programme must be split up into very short frames, each frame must meet with an active response, and knowledge of results must be immediately forthcoming. In addition, the required responses must be sufficiently easy for the student to get 90–95 per cent of them correct.

Skinner's rules are based on proven methods of animal learning behaviour. The argument is that man differs from, say, a pigeon, only in degree and not in kind, so far as learning processes are concerned. Some time ago this view was fairly generally accepted, but many authorities have now rejected it.

Since the advent of Skinnerian programming, evidence has been mounting against the method. Programmes have been written with very long frames or indeed no frames at all, with no active responding, no knowledge of results and with difficult responses. Results indicate that any type of programme may teach; there appears to be no need to keep to any particular scheme so far invented.

Apart from the behaviourists, are there no other learning theory experts whose work is relevant to our enquiry? It seems at least doubtful whether the present state of learning theory is such that it has any bearing at all on the situation in the classroom. If we are to obtain any crumbs of information whatsoever we must turn to the work of two distinguished researchers in the field: Pressey and Gagné.[1]

Pressey has launched vigorous attacks on those who extrapolate from the animal laboratory to the classroom. He is well known as the originator of teaching machines and programmed learning back in the 1920s, and he is in opposition to Skinner on many counts. According to Pressey, a textbook would teach just as well as a programme, if an equal amount of time and care went into its preparation. The advantage of the textbook would be the shorter time needed to work through it. Of course, a textbook of this type would more properly be called a *programme* and would bear little resemblance to the present genre of textbooks.

From Pressey's work we can draw at least one conclusion: a dominant factor in the success of a programme is the care that goes into its preparation. This conclusion, although very general, fits in with the more specific recommendations of Gagné, which we will now consider.

Gagné has been concerned with learning of several types, from motor skills to problem solving, and has established what he believes to be some necessary conditions for an effective programme. The first step is to analyse the material to be learning into a number of tasks and sub-tasks. The identification of these tasks may not be easy, and different workers may produce different analyses. The next step is the drawing up of a hierarchy of tasks, so that at every stage the learner has already completed all necessary material for the new task.

As an example of a task hierarchy, consider a training programme on Automobile Servicing. Let us take the task: 'Adjustment of fan-belt tension'. Before the trainee can be efficiently taught to master this task he must already have been grounded in several other tasks, e.g.:

1. Identification of the fan belt.
2. Use of spanner.
3. Identification of dynamo (or other source of adjustment).
4. Method of measuring or estimating distance, etc.

---

[1] Robert M. Gagné, American psychologist, formerly at Princeton University.

Note that each of the tasks cited is also the apex of a further hierarchy, for example, task 2 would be preceded by instruction on identification of nuts, selection of appropriate type of spanner, size of spanners, etc.

On first sight these methods of task analysis and hierarchy may seem of little application, or indeed to be self-evident and a prerequisite to instruction in any form. On closer investigation it is found that any curriculum can be analysed in this way and a suitable hierarchy drawn up. Although this might be judged a necessary preliminary to any course of instruction, in practice it is doubtful whether many teachers go to such lengths.

In summary, then, Gagné's procedure consists of careful analysis of what is to be learned, plus very exact sequencing of the individual items. We can see that Pressey's prescription for successful programming—the taking of great pains—is included in Gagné's more detailed criteria.

In common with other aspects of programmed learning, we have no proof that the theories just discussed are more watertight than any others described in this volume. None the less, most authorities agree that care in preparation and sequencing is vital to a successful programme, even though they may agree about nothing else. In any case, it is surely less artificial to look for criteria of this type than to endeavour to draw up elaborate rules for identification of good and bad frames.

It is astonishing to note the extent to which workers have been dominated by the concept of the 'frame'. Even when throwing the rest of Skinner's scheme out of the window, the 'frame' has been retained at all costs. Sometimes frames are long, sometimes short, but they are always present.

The practical teacher's point of view

As a guide to the reasons underlying the effectiveness of programmed learning, let us examine the method of operation of a good teacher.

First, our model will wish to give each student individual attention when he needs it. We are frequently told that this is just what a teaching machine can do, but this claim, like many others in this sphere, is dubious. It has, however, a kernel of truth just large enough to be worth some attention. Why and when does a pupil need individual attention? This question is worth examining further.

Some of the occasions when a pupil requires attention from the instructor are:

(*a*) When he is in difficulties and needs advice. (But would he, perhaps, learn to solve his own difficulties if he cannot lean on the teacher? This presumably depends on the teacher's skill.)
(*b*) When he has completely misunderstood the material and does not realise the fact.
(*c*) When he is in need of praise or acclamation for correct work or a good try.
(*d*) When he is bored or uninterested and needs motivation.

No doubt the reader can draw up a more comprehensive list, but this is sufficient for our present purposes. Let us see how well a teaching machine can cope with the list.

Item (*a*) is neatly circumvented by a good programme, the learner is never allowed to get into difficulties. If it is thought desirable that difficulties should be encountered and overcome, then this facility can be specifically written into the programme.

Item (*b*) is also catered for by a typical programme. It is to be hoped that the student will be kept firmly on the rails by the exposition in the programme. Should this fail, there is still the frequent question-and-answer which quickly reveals an inadequate grasp of the subject matter.

When we come to items (*c*) and (*d*) the programme is not nearly so efficient. Consider (*c*): what is the interplay between human and machine when the human is in need of praise for a correct answer or good try? For a start, programmes are not so keen on 'good tries'. The answer in the book or machine has to be fitted into a smallish space, and often there is not room for all possible correct answers, let alone incorrect ones, however meritorious the attempt.

What about the praise? The behaviourists maintain that the act of being right *and instantly being told so* is sufficiently rewarding to human beings. In passing we may note a desire on the part of behavioural psychologists to have it both ways: according to them the learning processes of man and animals are essentially similar, *but* man is reinforced by being given knowledge of results; animals are not. The unfortunate learner is to be equated with pigeons but is denied the gastronomic reinforcement given to the birds.

Not all programmes rely solely on knowledge of results. Some lard the frames with praise, e.g. 'Good!' or 'Well Done!' This procedure seems harmless enough, but it is doubtful if printed praise of this kind warms the hearts of many students for very long. On a down-to-earth level some programmes intended for young children have used more material rewards for good work. Sweets and trinkets have been tried, while more parsimonious experimentalists have used progress certificates or sticky coloured stars. In spite of these various attempts, for most practical purposes, straightforward confirmation of results is the nearest that a programme can get to an instructor's commendation.

It is worth noting that individual instruction, whether from teacher, machine or programme, always denies the student acclamation from his fellows. This is not the place to consider the social aspects of education, but we should always be aware that the acquisition of formal knowledge is only a part of the educative process, perhaps not even the pre-eminent part.

How does a programme or machine deal with item (*d*)? What steps are taken to emulate an individual teacher in alleviating boredom and increasing motivation? The answer to this question must be, 'None'. To combat boredom, the only weapons possessed by a programme are those built in originally. Possibly some adaptive teaching machine of the future will be able to diagnose boredom and apply corrective action, but at present no such machine exists. So far as motivation is concerned, the same argument applies, perhaps the programme motivates a given student, perhaps it does not. No programme can be highly motivating to all students all the time.

We have been discussing programmed learning from the point of view of *individual instruction*. Individual instruction does not just mean that each student can proceed by himself. On this basis, a common-or-garden textbook is an agent for individual instruction. No: unless we confine discussion to triviality we must mean teaching particular to a student; the course is tailored to the individual. From this standpoint a programme is seen as a pretty crude substitute for an individual tutor; once a programme is printed it is immutable. The reader may object that branching programmes offer alternative routes which cater for individual differences, but this objection must fail because the programme is still preordained; the student must fit himself at every stage into one of a few patterns.

Return now to our practical teacher. For the reasons listed, and no doubt many others, he would like to give his students individual attention. In theory, much of his time should be spent in this individual tutoring. In practice, what do we find? Large classes and cramped conditions conspire to reduce this activity to an absolute minimum. Now look again at the programme or teaching machine: in comparison with Socrates the programme shows up poorly, but compare it with an overworked teacher and we see it can supply some individualised instruction, sufficient at any rate to be a useful tool.

We have spent some time discussing the shortcomings of programmes and teachers in the context of individual instruction. Although limited, the extent to which programmes can cater for the individual is important for other practical reasons, as we shall see now.

A good teacher keeps his students busy. He may achieve this by persuasion, eloquence or even by brute force, but if a class is to progress it is essential that no time be wasted. Pencil-chewing, gazing into mid-air, pondering on last night's match or today's date are all pleasurable activities, but are not likely to be found in the good teacher's classroom. Rather we should expect to find an atmosphere of purposeful activity, where the ringing of the changeover bell comes as a surprise.

Our good teacher keeps his pupils busy; so does a good programme. There is, however, one difference: it is quite possible to be busy but not usefully busy. The dull child faced with a vigorous teacher may put on a continual show of activity. This activity may superficially be identical with that of his cleverer fellows, but in fact it is not backed up by the correct mental behaviour. Somewhere along the line the student has been left behind.

With a programme it is much more difficult to get left behind: the responses keep coming wrong and there is opportunity to retrace steps and eradicate the source of trouble.

We have then identified certain attributes of programmed learning which correspond, in some measure, to those possessed by the instruction given by a good teacher.

In addition to the points so far considered, a programme can supply the following:

(*a*) Massed practice on as large a scale as necessary.
(*b*) Examples of a trivial nature, too time-consuming for class work.
(*c*) Sufficient practice for everyone at, for example, naming parts of a diagram, etc.

The reader can perhaps envisage other points from his own experience, and may well conclude that programming has much to offer in these directions. Material of this nature can in fact be dealt with by a class teacher, but in general it would not be possible for each child to get the optimum practice, or indeed, even a fraction of the optimum.

The overall view

Primitive man acquired his knowledge in the hard school of experience, and if he learned badly the penalties were great. Nowadays we still go through life gathering knowledge, but at certain times, sometimes voluntarily, sometimes under compulsion, we are exposed to new material in an intensive fashion. The word 'exposed' is used advisedly; there is a regrettable tendency when we speak of 'teaching a student' to have in mind a process similar to filling a pint pot.

The processes of learning and understanding are little comprehended. Lacking a precise theory, it seems more reasonable to regard the brain as continually learning according to the stimuli reaching it from eyes, ears and other sensing organs. When we teach, conventionally or by programme, we are controlling the stimuli reaching the brain. According to the efficiency with which we modulate these stimuli, a student will learn or fail to do so.

A programme then, like any other method of teaching, is a means of bringing material to the attention of the student's brain. If we construct our material subtly we may induce activity in the brain which is conducive to learning.

Summary

Psychology at present has little contribution to make in helping us to decide how and why programming works, and how to make it work. Lacking a definitive theory, we can only fall back on tentative 'common-sense' hypotheses; these we must be ready to drop instantly if contrary experimental evidence is forthcoming.

Our hypothesis is that programming does supply a modicum of individual attention, especially in so far as students are enabled to proceed busily without waiting or distraction. To draw up a programme which will achieve optimum results we must pay attention to task analysis and hierarchy. At all stages in a programme the student must be able to proceed in one way or another; this must apply to the dullest students, not just the bright or average ones.

It may be thought by the reader that the advice rendered in this chapter is pretty sparse. It is always pleasant to be given an authoritative prescription for success, and indeed, programmed learning is not without its bell-wethers eager to lead their flock. Unfortunately no one has yet shown that their own particular trail leads anywhere at all, let alone to the hoped-for destination. One purpose of this book is to encourage thought and discussion about methods of learning which go under the generic name 'programmed learning'.

2

Linear programmes

The title of this chapter is primarily one of convenience. In the past, certain very definite rules have been proposed with which a linear programme was supposed to conform. The evolution of programmed learning has resulted in loss of rigidity of definition, to the greater advantage of programming in general.

A linear programme for present purposes is an arrangement of teaching material which a student can work with by himself; and with no more than minor variations, all students working the programme will cover the same ground. Note that:

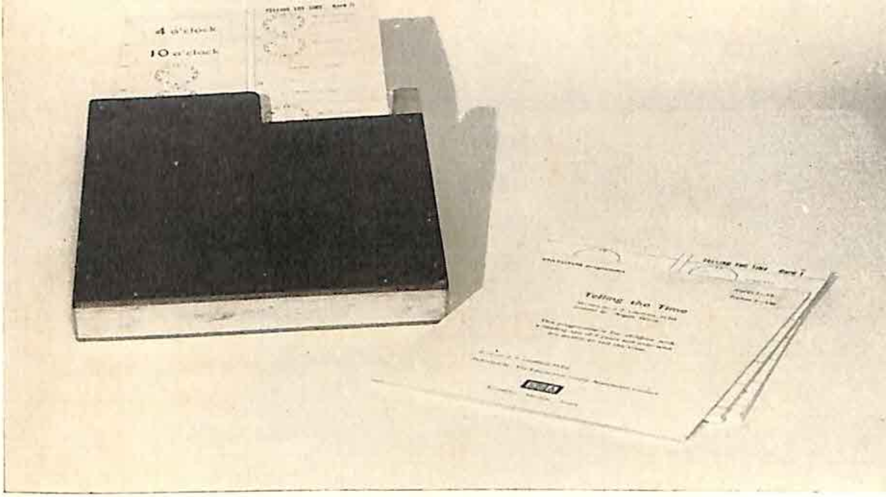
(*a*) The programme may be integrated with human teaching to some extent.
(*b*) There is no mention of frames, or length of frames.
(*c*) There is no mention of responses.

So much for my working definition. In practice, what are the prominent features of a typical contemporary linear programme? How does such a programme appear on first sight? Here is an example:

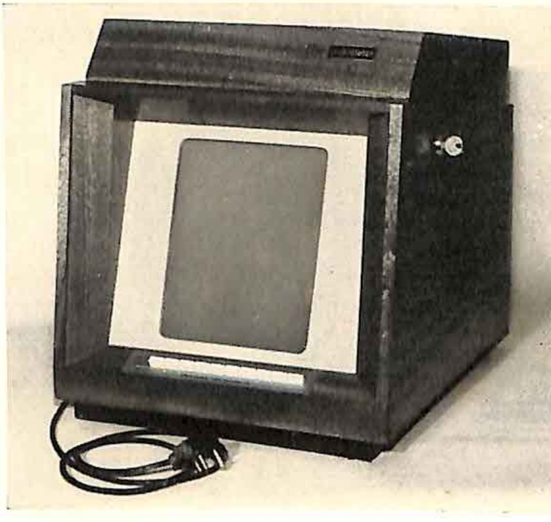
English Skills Card 1 Set 8

Answer is covered up until question is answered.
© J. Leedham

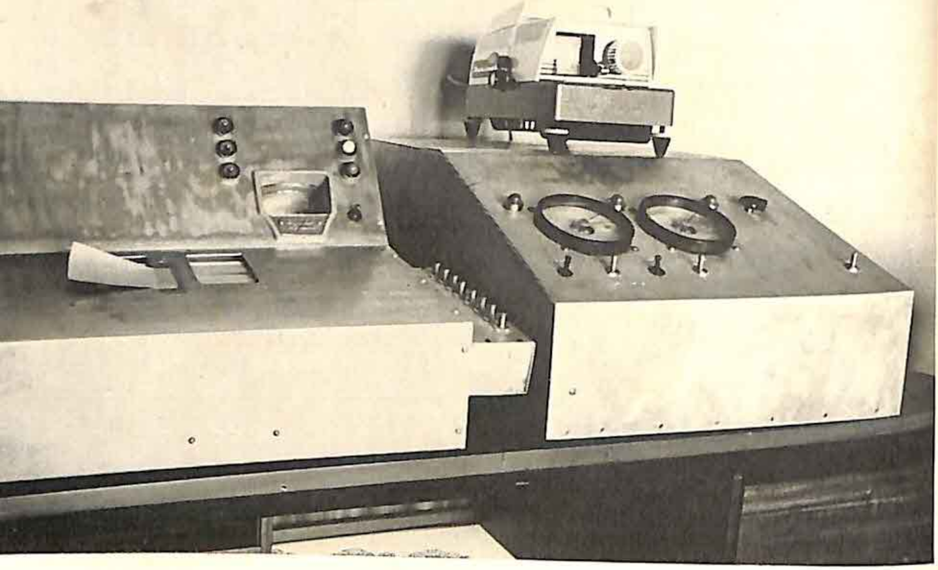
A 612	Q 612
ADVENTURE	*Adventure stories thrill me.*
(stories)	What stories thrill me?



Top
5. *The Promasks*
By disregarding anticheat storage and scoring facilities a programme can be presented in such a mask as this, where the pack is placed in the Promask box and withdrawn one frame at a time.



6. *Branching Machine*
The Grundy Tutor
In this machine an item of information is displayed and questions are posed about the content. Each question is ascribed to one of the buttons seen at the bottom of the machine. Correct selection enables the programme to proceed; incorrect selection provides further information and a chance to try again.



7. *The Group Console*

An electronic construction built by Dr R. W. Kind to the requirements of J. F. Leedham as a prototype for the full Group Console to be used later. In this device the left-hand console presents the information on running paper tapes and through a limited strip viewer. The multichoice buttons give a range of selection and automatic projection of slides enables a group to follow. The right-hand console monitors the proceeding. The consoles are linked by an 8 ft. composite cable.

8. *The Autotutor, Mark 2*

This machine works in the same way as the GrundyTutor. In point of time it preceded it and was imported from America.

A 613 (my) ADDRESS	Q 613 *My address is in the telephone book.* What is in the telephone book?
A 614 ADVENTURE	Q 614 *I had an* AD---TURE *with the lion at the zoo.* Write out the word.
A 615 ADDRESS	Q 615 Add ADD to RESS, and make a word for the place where you live.
A 616 ADVENTURE	Q 616 Write out these letters to make a word meaning 'an exciting event'. EVTREUDNA
A 617 ATTEMPT	Q 617 *He made a brave attempt.* Which word means 'try'?

The striking aspect of most programmes is their piecemeal nature; they are divided up into vast numbers of items called 'frames'. Each frame is a snippet of information, often posing a question directly or elliptically. This brings us to a second universal feature: the response.

Responses are of two types: constructed or multiple choice. An example of a Constructed Response frame is

459 The capital city of the U.S.A. is named after the first President of that country. The name of the first President was ......
....

whereas a similar frame based on the Multiple Choice format could look like this:

459 The capital city of the U.S.A. is named after the first President of that country. The name of the first President was

(*a*) Abraham Lincoln
(*b*) New York
(*c*) George Washington
(*d*) Robert E. Lee

In general, frames are kept short; the learner is not to be confused by exposure to large quantities of material at once. Many programmers would like to have only one frame in view at a time, and a teaching machine can accomplish this. (See Plates 1–6.)

Most programmes appear in book form, and for reasons of size it is usually impractical to have only one frame on a page. Various compromises have been adopted, both for frame position and answer position. (It is recommended that the reader work through programme extracts on pages 41–48.)

Now the reader will have noticed that although frames, questions, responses are the very stuff of such programmes—and the same applies to virtually all available programmes—the definition given above does not mention these items. There is a very good reason for this. It is perfectly possible to draw up a teaching programme which contains no frames, no questions, no responses, and such a programme may teach effectively. As we shall see later on, organisation of material is probably more important than any individual trick-of-the-trade. It is regrettable that many of the statements in this volume are hedged about with words such as 'may', 'perhaps', 'possibly' and so on, but such caution is inescapable when discussing a technique in such an early stage of development. This is not to say that the usual frame/question/response mode of programming has no merit. It certainly possesses one massive advantage: a programmer's work can readily be checked against students' responses, and this reveals areas of the programme in need of revision. If programmed learning has nothing else to commend it, it should always be regarded as useful for emphasising the principle of feedback in education. This process, whereby a teaching method is changed as a result of accurate analysis of student behaviour, has supplied a much needed corrective to primitive pedagogic habits.

Various experiments have been conducted to determine the value of responding. Results (as apparently in nearly all experiments into programmed learning) are inconclusive, but what we can say is that:

(*a*) Constructed response frames generally take longer to answer than multiple-choice frames.
(*b*) Frames requiring no overt response are worked faster than either constructed response or multiple choice.

Most programmes contain an instruction at the front strictly enjoining the pupil to write all responses on paper (or on the programme if the publisher is an optimist). We might assume from this that the actual writing of responses—even if the response consists only of say '(*b*)'—confers some benefit on the student. If so, no one has yet proved it. On the other hand, there are several excellent practical reasons for having your students commit pen to paper:

1. It enables the teacher to check that the student has done all he says (unless he has just copied down the answers).
2. If a student does no writing it is often difficult to convince people work has been done.

It is instructive to observe the behaviour of an experienced programmer who is studying a new topic via someone else's programme. Does he write his responses down? Not usually.

3. There can be little doubt that some people learn more thoroughly when they commit answers to paper. The reasons for this are almost certainly complicated, but the fact remains.

What can be programmed?

A criticism still encountered nowadays is that programming is all very well for factual subjects but obviously inapplicable to less mundane areas of knowledge. The criticism is worthy of discussion, provided argument can be kept away from the emotional plane. Let us for a start agree on what constitutes a factual subject: presumably Mathematics, Physics, Chemistry, Biology, English Grammar, Latin, Modern Languages, Musical Theory, Engineering Drawing, Economics, Geography, History, etc., all contain much factual matter.

Even if we lose the argument there is still plenty of programming to do, but let us look at what is left: Philosophy, Ethics, English Literature, Art, Football, Musical Appreciation, Politics, Religion, etc. Now, it is quite a reasonable standpoint to say that some of these subjects should not be 'taught' at all. A person who is taught that Bach is good and Jerome Kern not-so-good is not being instructed in the appreciation of music, he is being fed pseudo-facts, and a programme could do it just as well. Probably a suitable machine could do the job infinitely better by coupling, for example, electric shock with undesirable behaviour, such as liking 'pop' music. This is, of course, a lightweight analysis, and no doubt many music teachers recoil in horror from such aspersions on their methods. But no matter how detailed the reasons and arguments that are invoked to demonstrate the superiority of Bach, there must surely at some stage be introduced matters of individual judgment, and on these matters a teacher seeks to impose his views on his students.

Examination of the teaching-methods used in other non-factual subjects reveals that in general the teaching is of a factual nature: 'Shakespeare writes good plays', 'Rembrandt was a fine artist', etc.

No doubt it will be said that such pseudo-facts are not taught as baldly as this, that reasons are advanced for such statements as 'Shakespeare writes good plays', for example, 'the plays have endured a very long time', 'experts are agreed on their merits', 'the poetry is superb', 'the plays are worked out with great dramatic skill', 'the characters are superbly drawn', 'the plots are extremely ingenious'. But all these statements are either facts or pseudo-facts, and so will be any reasons backing *them* up. I am not here disputing that there is a non-factual element in such subjects as English literature. The point of my argument is that, willy-nilly, much of our teaching at school level consists of the indoctrination of facts and pseudo-facts.

In essence, then, a vast proportion of material has to be taught factually if it is to be taught at all. No doubt in higher education much goes on that cannot be so classified, but it is doubtful that such a procedure can be followed without a solid grounding of factual knowledge.

One final point on this topic: the word 'fact' is often used as if it stood only for such statements as 'grass is green'. In reality, factual knowledge reaches to the extreme limits of man's intellect, and whole bodies of knowledge, entire subjects, consist of interwoven echelons of facts. Only years of patient fact gathering could have led to the utilisation of atomic energy. Admittedly the scientists and engineers involved in this work needed to be able to discriminate useful and relevant results, but none the less each step up the pyramid of progress had to be based on the accumulated factual knowledge already achieved. It is not usually *sufficient* just to know facts, but it is frequently a *necessary* condition for fruitful work.

Is learning easy?

Having decided that parts of most subjects can be programmed, it is now opportune to look into the question of the difficulty of learning. There is in nearly all of us something of the Spartan, especially when we act on behalf of other people. There is a supposition that for work to be effective it must be *hard*. Especially is this true of learning. The idea that a subject might be mastered easily strikes us as almost immoral—if a thing seems easy, then we reckon there is not much value in it. And yet, consider how we recognise that rare genius—the brilliant teacher; we say, 'He makes difficult things seem easy', or 'He taught us to understand; the subject was complicated but he made it seem simple'. Could it not be that learning is intrinsically *easy*, it is basically *simple*, and our Spartan outlook is merely recognition of the mediocre standard of much teaching?

The reason for going into this question is that, by and large, programmes are easy (or their authors intend them to be so). To some educators this is offensive for the reasons outlined above.

Surprisingly, we do have some evidence on the subject of frame-difficulty, and it turns out that students do not learn so well if the frames are difficult or, what amounts to the same thing, if too much new material is contained in a frame.

It seems to be extraordinarily hard to write things down simply, and the tyro programmer's usual mistakes are:

1. The material has not been analysed sufficiently well.
2. The frames are too crowded with material.
3. The required responses are too difficult.
4. The programme does not flow smoothly from one frame to the next.

In general, if the beginner aims at making a programme 50 per cent easier than he thinks necessary, a lot of rewriting may be avoided.

Sequencing

At any stage in a programme the student must be in possession of all the knowledge he needs in order to proceed. This applies right from the start, and it is good practice to draw up a list of required preknowledge. For example, a programme on *simultaneous equations*[1] states in a preface that:

> 'It is assumed that students are able to solve simple equations of the type *ax* plus *b* equals *c*, and that they can handle negative numbers.'
>
> 'The student should already be familiar with some method of subtracting expressions or equations.'

Having established that students come to Frame 1 with the appropriate background, it is up to the programmer to ensure that a body of knowledge is built up sufficient to cope with responses at every stage. The programmer must at all times beware of requiring the student to respond to a question which is in reality unanswerable because of some omission. It is all too easy to assume mistakenly certain outside knowledge or, alternatively, to leave a gap in the thread of instruction. The first of these faults is particularly liable to arise when making a praiseworthy attempt to add general interest to the programme. For example, following a number of frames on Boyle's Law, we might see:

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[1] Austwick, *Simultaneous Equations*, Methuen 1963.

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25 In an internal-combustion engine the gas is compressed when the piston rises. At all times when this is happening we can say that . . . is constant, provided the temperature remains unchanged.

Anyone who worked the previous frames should be able to insert the correct answer (pressure × volume) in here, even if he knows nothing about the internal-combustion engine. This is, however, bad policy, because you want your students to read the frames, not just fill in blanks. In addition, there will be a significant number of conscientious students who assume that all your frames should be completely intelligible on the basis of the programme so far. Such students will study the first sentence of the frame in the hope the frame will develop a full meaning for them; lacking the necessary familiarity with engines, they will waste much time, and to some extent become discouraged. It is a wise policy to ensure that students travel smoothly through a programme; we should try to avoid engendering a strong emotion of any kind, and an ill-constructed programme can rapidly induce hate and fury in good measure.

As an example of leaving a gap, take a programme which has so far established that people in China, Burma, etc., eat rice, we may then read:

---

77 Most inhabitants of Asia are unable to obtain meat and dairy products to eat. Their diet consists almost entirely of cereal crops like . . .

This is a poor frame unless the students already know what *cereals* are. Many people equate cereal with 'corn-flakes' (maize), and it is generally a mistake to introduce technical terms without adequate definition.

Summary

A linear programme is a self-instructional medium aimed at a given class of students. All the students will work through the same substantive material. A programme is carefully arranged so that there is a very gradual progression from easy to difficult.

Factors generally recognised as important are:

1. Careful sequencing with no gaps.
2. Copious explanation to ensure that the programme is not too difficult for any intended student.

Questions and overt responses may or may not be included. They will certainly be very useful in validating the programme (of which more will be said later).

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3

Revision and comparison of programmes

A teacher who is prepared to work out a programme, revise it with individuals and then try it out with a group of up to twenty will be in a position to consider the effectiveness of the programme in his own classroom. It may well be that for a considerable length of time such a programme when used by the originator, at the stage and for the purpose he devised it, will be extremely successful. He may, however, be crestfallen when it is tried in wider circumstances, for almost certainly it will be far less successful.

Two examples might serve to illustrate this. The first concerns a programme on Area used with quite able 9 to 10-year-old children. The programme was developed and altered by the class teacher in order to provide the able children with this work. Eventually over half the class was able to accomplish the programme successfully. The programme was revised slightly and issued for use with third-year children in several schools. The error rates promptly rose, some schools found it effective, some did not. The programme underwent four complete revisions in an effort to reduce error rates and deal with the teaching of concepts rather than of rules, but none the less, its final form appears to be much more effective even in the teacher's own room, where it is used with more certainty by more children. This programme has now become three distinct programmes, and the abler children handle all three, the less able, two and if occasion warrants it, some may only attempt one. It is necessary to stress that the revisions to achieve this involved many children, many alterations and several reissues of the programmed booklet. It is this process which bears hardly on the practising class teacher who lacks the time and facilities to do this revision.

The second similar circumstance concerns a programme in map-reading and representative fractions. This programme, devised in a highly individualised fashion by a most experienced teacher, taught the topic in 120 frames including the necessary computational skills. The programme finished with some 50 review items. This format and presentation proved highly successful with unstreamed 11 to 12-year-olds and achieved an error rate of below 7 per cent. Trials outside the classroom in limited circumstances were partly successful, but translated into booklet form and used more widely this proved to be less successful, and considerable revision and illustration were again needed.

The question of illustration needs amplification here. Experience shows that the revision of a text must involve the revision of the illustrations. Some programmes for the younger pupil gain greatly by illustrations, and the task really becomes *programming* illustrations. The best way we have discovered with this has been to accumulate sketches and photographs associated with the programme and to revise and sequence them as part of the programme revision.

Before experiences gained with programme validation are dealt with, one point needs to be clearly made. Some programmes devised carefully, tested with small groups, revised and again presented, may prove to be quite unsuitable with pupils of differing backgrounds and may need quite radical revision. One such programme was on Volume, for 10 to 12-year-olds. Presented with a kit of cube blocks and following on the use of structured apparatus, it had a useful life in two schools. Tried out in revised form with schools who did not use structured apparatus, it failed to convey the necessary concepts, even with the use of the cube blocks. Success was finally achieved only when the programme format was completely revised by using large photographic illustrations to introduce area/volume concepts, and developing the concepts by photographs to the stage where volume apparatus could be introduced successfully.

The question resolves itself into the relative usefulness of a programme prepared by a teacher for his own use and a programme produced for use over a wide field. Between the two, experience of the Research Unit at Leicester suggests that the teacher's programme will be the most effective for him, but that the programme which has undergone wider testing and validation will be most effective for general use.

Programme testing and validation

A great deal has been written on this topic, but it is difficult to obtain information about the precise procedures of test and revision which have actually been carried out.

Testing a programme can be looked at in two ways. First, it should be tested for its *internal* validity. Is it consistent with its declared aim? Are the step sizes reasonable, do the reviews occur correctly? Does it teach what it sets out to as measured by pre-test and post-test? More important, can this learning be transferred to similar situations by the pupil? Is its error rate low, is it accomplished in reasonable time by all pupils or is there a large time span? Is it meaningful to its intended pupils? Its *external examination* refers to its comparison with other methods or programmes when actually in use.

Dealing with internal validity is the simpler. A programme can be examined by inspection and discussion as to step size. The error rate in the answers will call for attention. Consistency and the review items should match together well. A correct development of its aims will be revealed by the responses to the reviews. As already suggested, these items can be provided without answers in order to confirm progress. The advisability of breaking down a programme into small sections and testing each section for its consistency with the entire programme is often urged. This may ensure the programme has a balance and proceeds with regularity, but it is not likely to achieve much more. After all, the usefulness of a programme lies in the results it achieves. A programme which apparently achieves all the requirements of logical development and structure has finally to prove itself with the student.

In order to assess the worthwhileness of four different programmes on

1. The Geometry of the Point and Line
2. The Language of Sets
3. The Atmosphere
4. Germination

(about 200 frames each), original testing was attempted by sending programmes out into nine schools, using anti-cheat devices. Collection of machines and material on time and in sequence proved very difficult. The programmes were then produced in booklet form. Eventually the material was tried out with small numbers of up to ten in some twenty-one schools geographically separated over the country and chosen across the range of private and state education.

Small numbers were used to ensure better supervision, since the material was not cheat proof. It has been our experience that copying of the answers occurs on the ratio of 1 : 1, that is, one attempt, one copied answer. This is based on programmes administered under observed conditions. While this does not appear to prevent learning, it can be very misleading when a writer is attempting to validate a programme. Indeed, the group of four experienced programme writers, all practising teachers, agreed that programmes returned from different areas showed a great dissimilarity in achievement. A programme administered in a well-known public school apparently as a 'prep task' varied in its performance rate to the extent of near absurdity. Indeed, it became quite clear that the circumstances of administration of a programme under validation could be a decisive factor. Accordingly, the conditions of administration were adjusted so that only four or six copies of a programme were tried in any one school. Even so, review of the error rates needed to be carefully carried out in the light of the administering teacher's comments. Programmes needing validation beyond classroom use could employ the following testing procedure:

1. A review with individuals as already outlined.
2. A distribution of the revised programme in groups of six

in as many suitable localities and populations as possible. Ten geographically separate units are useful, but it is difficult to get material returned on time from distant areas, with whom one is only in touch by correspondence.

3. After revision, administration of programmes in groups of thirty in three separate target areas.
4. Revision with similar individuals to those first used.

With the necessary alteration and control of the programme such a test schedule appears to be the maximum that is possible without full-scale support by publishing houses or educational authorities. Bearing in mind the cost of alteration and duplication, the delay in obtaining completed material back from schools, the procedure outlined above appears to be the maximum possible for the individual programmer. It is provision of this type which makes programme production 'inspired drudgery'. Even after publication a programme must stand in need of considerable further revisions. The programme produced in the teacher's classroom for his own children would probably still rate highly, but few teachers will ever have time, energy or even the money to prepare the several programmes they would be prepared to use. One unstated problem in programme administration is this: a successful programme will quickly advance the pupils, who will then be ready for more far sooner than before. Probably this is the best comment to make on programme validation. A successful programme will create its own demand.

4

The teacher and the programme

In the early days of programmed learning—the Golden Age, some might say—teachers were regarded as the one stumbling block that could come between the harmony of pupil and programme. It was felt that given sufficient programmes and machines of the right calibre, the teacher could be safely relegated to the role of disciplinarian and counter-of-heads, with the probability that even these tasks would eventually be taken over by some piece of electronic hardware.

Understandably enough, teachers showed no more joy at the vision of their profession being automated out of existence than any other body of workers faced with this prospect. Furthermore, not all or even most of their protests were made on the grounds of self-interest. It was argued that education by machine was a soul-destroying procedure, and that in any case programmes could only teach facts, and this was not the real stuff of education. Other attacks were made on the theories underlying programmed instruction: human beings, it was said, are very different animals from pigeons, and extrapolations from the psychological laboratory to the classroom were completely unjustified.

It now appeared that the psychologists did not wish to put the teachers on the streets—far from it; programmes would take over the drudgery of routine teaching, and the thus unfettered teacher would be free to 'enrich' the subject matter. The educator was not to be made redundant, but on the contrary, he would enter a new and higher plane of activity, where all his energies would be free to meet the challenging tasks ahead. Students tutored by programmes to hitherto undreamed of heights of knowledge would be ready and willing to absorb enrichment which only the human mentor could give them.

Unfortunately a definition of 'enrichment' is hard to come by in this connection. Does it mean embellishment? Or ornamentation? Or the supply of background knowledge? Possibly after a programmed course about the River Thames the teacher recounts his experiences of the Woolwich Free Ferry. This is perhaps a legitimate educational activity, but surely such embellishment or enrichment is not intended to be the fulltime activity of teachers? As for background knowledge, there seems little reason why a programme should not deal with this just as well as it treats the main subject matter.

Where, then, does the teacher stand in regard to the use of programmed materials? Is he to be solely responsible for those peripheral aspects of school life that presentday machinery is unsuited for, is he to concentrate on the supply of 'enrichment', or is there a further alternative which is not degrading to his profession and at the same time makes use of auto-instructional methods? It is hoped that we can examine this question with a view to finding a reasonable balance, a rationale which fully utilises the talents of both man and machine.

As a first step, let us examine some of the goals of education. In the United Kingdom every child receives at least ten years of fulltime education; many receive eleven years, and an increasing minority receive thirteen years and more. We hope that no matter what the age of leaving is, certain attributes will be possessed by every departing pupil. These attributes include the possession of some moral and ethical code, a factual knowledge of several areas of study, the ability to reason on the basis of known facts, a capacity for self-expression and so on. Teachers will differ in the relative importance they attach to these and other educational goals, but most will agree that there are many facets to education, and all are of *some* importance.

The word 'fact' seems to have acquired derogatory overtones; there is a tendency to deprecate knowledge which consists of a 'string of facts'. Examiners traditionally set searching questions aimed at sorting the reasoning sheep from the fact-learning goats. It is difficult to understand this prejudice, especially in a modern industrial society which relies so heavily on mass communication for its opinions. Public opinion polls frequently produce evidence that should horrify us: vast numbers of people do not know the name of their M.P., or what party he belongs to; many do not even know who is the Prime Minister. Electors are asked to vote in general elections on the basis of, for example, their opinion on the merits or demerits of nationalisation. How many know what government created the first nationalised electricity undertaking?

Surely we must accept that facts are worth knowing. Factual knowledge is a prime requirement in the study of most subjects, as is evidenced by scientific investigation. Much scientific work consists of accumulating facts; it is hoped that eventually a theory will emerge that fits the facts. Alternatively, we produce a hypothesis and then design experiments to give us facts for testing our theories. The facts are the arbiters and the hypothesis is quickly rejected if the factual knowledge we obtain indicates that our premises are unsound. Throughout his lifetime Tycho Brahe recorded countless astronomical observations, as a result of which Kepler was able to revolutionise man's view of his universe. Should we criticise Brahe for accumulating a string of facts?

The purpose of this preamble is to suggest that the learning of facts is a worthy part of the educative process, and to attack a teaching machine or indeed a teacher for inculcating facts is misguided in the extreme. If it is accepted that facts are worth knowing, then here is one area where programmed learning can be useful. Even critics of the method agree that facts can be taught efficiently in this way, so we can now turn to a different educational goal. Our programmes can teach facts, can they teach students how to use facts?

Any discussion of *reasoning* or *thinking* is hampered by the inadequacy of our knowledge of these processes. It is accepted that as a child develops he gradually increases the number of concepts he can cope with at one time. None the less, children differ widely in their ability to reason, and it is at least arguable that our present educational system does little to help the child who does not apparently possess this faculty in great measure. We delight in observing the gifted child make a mental leap, and we dismiss as dull the pupil who appears incapable of following suit. Suppose we say to a class, 'Frogs and ducks both have webbed feet, why is this?' Some will give the right answer, some a wrong answer, still others will give no answer at all. There may well be any number of complex psychological reasons why one child is better at such inspired guesswork than another.

Some time later, after instruction, we give a test, and in it we ask why the feet of ducks and frogs are webbed. Nearly everyone now answers correctly. Should we distinguish in our marking between those who originally guessed the correct answer and those that did not? Some teachers would like to, and would justify this wish by saying that certain pupils had only learned the information 'parrot-fashion'. This is taken to mean that those pupils originally wrote down words without any knowledge of what sense the words make in context. I would suggest here that provided a pupil *now* understands why *such-and-such* is *so*, it matters little whether he 'guesses' the answer himself or has it told to him. The important thing is the understanding.

It should be emphasised that the above paragraph assumes that the learning criterion is the knowledge of why, for example, frogs and ducks have webbed feet. If, on the other hand, we wish to teach *reasoning*, that is, we wish to have all our pupils make mental jumps, this is something very different. We must at the outset decide whether we wish to teach various interrelationships between facts, or whether our aim is to teach reasoning power. It is clearly vital to distinguish these two separate concepts, yet how often do we find that our lessons confuse the separate targets?

Only a few children are natural ball players, yet by practice and coaching other children are enabled to reach a high standard of play. Similarly, some people are naturally good at reasoning and others are not. An obvious inference is that by practice and training we can raise the standards of reasoning just as we can those of cricket or tennis. But do we do this? In the average school curriculum there is no training in logical thought at all; it is presumably hoped that Latin, Mathematics, etc., will supply the need, but obviously this does not happen for vast numbers of students. The reader may well ask at this stage what relevance these speculations have to programmed instruction. It will be argued that the use of this medium can go some way towards improving reasoning standards in general.

One of the original advantages claimed for programmed learning was that a programme was far superior to a human teacher when it came to giving extensive practice. This claim seems to be irrefutable with any normal pupil/teacher ratio; by its very nature a correctly graded programme is ideally suited to practice of any kind. If we assume that reasoning can be taught at all, then surely practice is the key to success, and the weaker the pupil, the more practice he needs. There would not appear to be any difficulty in writing a programme of this nature, and the results might well be startling. If we can both teach facts and the manipulation of these facts into logical patterns we are certainly achieving valuable educational goals.

Having examined some areas where programming has strong claims, let us now look at the other side of the coin. Self-expression is an ability which education must foster, and the cultivation of this ability is completely ignored by contemporary programmes. The so-called Constructed Response mode generally requires a student at most to write down a few words; in the Multiple Choice format the response frequently consists of selecting a letter of the alphabet which designates the chosen response. Neither of these systems is likely to produce students with much competency at expressing themselves. Even the minimal responses just outlined are eliminated in the 'Covert' and 'Reading' modes, but there is little point in mourning the loss of this tiny amount of writing.

Why, we might ask, do programmes call for such granular responses? The reason, of course, lies in the self-checking nature of the medium: the student is apprised of the correctness of his answer, and this is easy to do if the answer is strictly limited in form. If, however, the student submits lengthy and detailed answers, how can these answers be verified and criticised for style, etc.? Rather than attempt such a difficult task, the problem is circumvented by restricting the responses to a small and convenient size. This is not to say that auto-instruction could not cope with extended responses; obviously it is impossible to cater for every conceivable answer which might be produced, nor could a single 'right' answer be presented for comparison, but is it feasible that students should be given criteria for viewing their own extended responses? Even given this, there would still remain the problems of style, grammar, etc., and any programme attempting to deal with these questions would inevitably be hopelessly complicated.

Clearly the answer to requirements of self-expression is to have the programme periodically call for extended responses and for these to be shown up to the teacher. It is reasonable to expect that ample time will be available for individual discussion of such answers, the programme having shouldered a substantial part of the teaching load. A further useful exercise would be to require the building up of a coherent set of notes as the programme is worked. These notes would periodically be examined by the teacher, and such a process provides practice of incalculable benefit to the student. Here are some areas where the human teacher can utilise his unique talents, and make use of the liberating effects of programmed learning in order to teach his pupils valuable abilities. This is not 'enrichment', but a vital and essential part of the process of education.

One field in which a machine or a programme is unable to operate is that of *discussion*. Successful discussion is a valuable educational tool, bringing in a variety of sociological factors and emphasising the necessity for clarity of verbal expression. Now discussion between fellow pupils may well be of some use, but it is unlikely to reach the level of effectiveness that can be achieved under discreet guidance from a competent teacher. Discussion is essentially a matter of facts and of reasoning from facts; if the ground has been well prepared by a suitable programme, subsequent ensuing discussion may be led by the teacher in such a way as to reinforce strongly the material learned. At the same time the practice given in composing verbal argument is useful in its own right.

It can be argued that the things we have discussed so far as being within the teacher's province—marking essay-type answers, examining notes, leading discussion—are all things that teachers are doing now and have done for a very long time. This is undoubtedly so, but the present contention is that there is not normally sufficient time for these jobs to be done at a uniform high level of efficiency. By using programmes where they are appropriate, teachers will be relieved of much arduous and routine labour, pupils will in general cover ground faster, and more adequate time will be available for the activities cited.

How about encouraging an acceptable moral and ethical code; should this be allotted to man or machine or to both? This, of course, begs the question of what constitutes the desirable terminal behaviour, and it is not the intention to discuss such topics here. It can, however, safely be said that programmed instruction forms a powerful vehicle for *indoctrination*, for good or for bad. Any moral teaching is suspect in so far as it reflects the prejudices and inhibitions of the teacher, and this can be said equally of programmes and of human teachers. We can perhaps leave this question with the observation that the use of programmes in this connection primarily depends on an agreement about what is to be taught, rather than on whether the medium is appropriate to the subject.

It is interesting to note a dichotomy which appears in argument about which subject matter can be programmed. Programming 'experts' (often knowing little about teaching) suggest that anything which can be taught, can be programmed. Opponents of programming (often knowing little about programmes) proclaim that there is very little that can properly be programmed—a little science and mathematics perhaps, but no more. Where does the truth lie, with the universalists or the exclusionists, or somewhere in between? It is likely that both camps are equally right or equally wrong; consider the following fable.

Once upon a time a man invented a transport machine which he called a *bicycle*. The inventor was very proud of his device and soon gathered round him a number of *salesmen*, who travelled the world far and wide extolling the virtues of the *bicycle*. According to the *salesmen*, here was a transport machine of universal applicability which would revolutionise man's methods of travelling and make the world a far better place to live in. Some people believed the *salesmen* and bought *bicycles*, but they were not completely satisfied, as the machines were not very well made and did not live up to the glowing claims of the *salesmen*. A number of *critics* also appeared, saying such things as 'Bicycles are no good for climbing stairs, or for crossing the sea, or for travelling very long distances; therefore they are no good at all.' To which the *salesmen* replied, 'But you can fit square wheels for climbing stairs, or better still live in a bungalow, and we sell paddle-wheels for crossing the sea on a bicycle and motors for travelling long distances.' And the ordinary customer was bewildered, but quietly experimenting by himself, developed a rationale whereby the bicycle was used for the many journeys where it was convenient. The inventor retired to his laboratory in disgust and commenced building a new device to be called an *aeroplane*.

The purpose of this cautionary tale is to suggest that each teacher who honestly examines programmed methods will find out if the methods are applicable to his subject, and if so, to what extent. It seems likely that most teachers can usefully incorporate programmed learning into some parts of their courses, and by so doing will improve the efficiency of their overall teaching.

One must at all times be on guard against the forceful salesman or the ardent adviser. Programmes are not a universal elixir for curing all teaching difficulties overnight. The whole tenor of this volume is based on the point of view that programming should be an *adjunct* to a teacher's work, and that the best results will be achieved by so using it.

PART TWO
Programmes in the Junior School

5

The justification for using programmed material with younger children

Children aged between seven and thirteen years vary widely in their maturity and attainment. Because of this, their schools have the responsibility for dealing with the children on as individual a basis as possible. This responsibility has usually not been met because of high numbers, streaming and selection at eleven plus. A new attitude to learning has spread into junior schools, which are accomplishing much in the face of large numbers, and great progress is being achieved in areas where the eleven plus has been absent for some years. This new spirit encourages enquiry, discovery and a more adventurous pattern of work. Programmed learning, at first sight, implies that 'learning', whatever that means, can be 'programmed'. Might not its introduction into the schools lead to a rebirth of formalised instruction? At the very outset we should consider the nature of programmed learning and ask why and how it can serve the school.

A simplified statement about programmed learning could be made as follows:

> There is a careful consideration and analysis of a task, and the materials or experiences to be learned are presented in a graded sequence. This sequence is organised in order to ensure that the pupil knows he is proceeding correctly. The task must be

capable of definition, and, for younger pupils, should be concerned with doing.

The analysis of the task

With a properly produced programme the amount of preparation is likely to have been much greater than that of other instructional media. The reason lies in the number of alterations necessary in programme revision and in the number of 'steps' into which the material has been analysed. This careful grading of the material is often criticised on the following grounds: it can lead to trivial learning because the amounts to be learned are insignificant. Even if learning occurs, the condition of the child's learning can cramp his initiative and lessen his potential, or so it is alleged. How true is this in actual practice? It has been possible to observe many children who welcome work with a programme as a relief from the constriction of classroom routine. Others, possibly the majority, view programmes with the eye of cheerful optimism. Possibly, because programme work is new, or because it has other advantages, we are far more likely to find a child eager to carry on with a programme than we are to find one bored with the prospect.

It is unfortunate that educationalists frequently suggest that inspiration can replace effort. It is the inspired *worker* who achieves. Whenever we write, or talk about, our children in school we always present the ideal situation. We say that the child is there to 'discover' and illuminate his budding intellectual growth with self-achieved discoveries. We say that our job as teachers is to create the atmosphere and attitude which lead to the occasion of these 'discoveries'. A little honest introspection may cause us to reflect that in classes of forty or more, often working individually or in small groups, the child's chance of learning by discovery might be somewhat less than his learning from our instruction. Discovery situations need organising and the child must be at the reading and reasoning level to take advantage of them. The true function of a programme used in school is to act as a guide on the path to discovery, to ensure that the child is able to absorb and assess correctly, and to relieve the teacher for some part of the learning process which he is prepared to delegate. The programme, whether in booklet, pack or machine form, is only likely to succeed where the teacher knows the programme, has sympathy with its aims and is using it specifically as an aid.

Confirmation for the pupil

Whatever other objections might be advanced against programmes in schools, one feature stands out clearly as an advantage. The programme accepts the liability for the child's failure. Unlike the teacher or the textbook, its underlying thesis is this: If the child is capable of understanding the earlier steps of the programme, then by assuring him of his continued progress it is possible to advance him to the desired end. If there is a failure, then the failure is not the child's but the programme's. But this can only be true if the child has the correct attitude towards the programme, and none save the teacher is capable of ensuring that. When we consider the relative failure to achieve a decent standard with our basic skills among the slower children, then one particular virtue of a programme is highlighted. It is patient, as patient as is needed by the pace of the child who learns. It enjoins success, it depends upon success. This at least is in keeping with our progressive school's outlook.

The Task

With the change from class instruction to small group or individual practices, there has come a welcome relaxation from the classification by examination. Beforehand, it was customary to use instruction for grading of one sort or another. The purpose of a programme, however, is to use learning to the advantage of the child. Again, it is only the teacher who is likely to be able to know what skill is needed or at what stage a particular programme can be used. This suggests quite definitely that the tasks to be programmed should be explicit, the content of programmes should be specific and that they should be short.

These then are some of the reasons for introducing programmes into schools. A good programme can act as an aid to a teacher; it can ensure that the child has the basic knowledge and skill which will be required in 'discovering'. It should act as a guide to discovery, but it is only likely to be successful where it enjoys the support and sympathy of the teacher. The fact that a programme is designed to ensure success and is ever-patient ought to ensure its welcome in the overtaxed classrooms of today. With the increasing trend towards non-streaming and individual work, the teacher needs material designed to accommodate the varying learning rates of his children. There are many tasks within the school which are capable of being quite clearly defined (e.g. set notation, map reading, reading, classifying), and for these the programmes should be short, to the point and capable of being readily handled or modified by the teacher.

6

Preparing a programme for younger pupils

At this stage it appears sensible to demonstrate what a child might be expected to face when he works with a programme. The excerpts below are drawn from programmes written for younger children. The reader is asked to cover up all the answer column and to check his attempt to answer a question after each genuine effort.

From a Programme Written for 11–12-year-olds, dealing with the concept and measurement of volume

The child first conducts various experiments to do with conservation of volume.

(It has not been possible to include all the programmed illustrations in these examples. A typical page is reproduced in Plate 13, facing p. 109.)

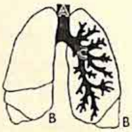
1 This cup was FULL of water. All the water is now spread on the SURFACE of the ground. When was there most water? Before it was spilt A After it was spilt B Both the same C	
	C

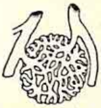
2 When the cup was full the water was all together. When the cup was tipped up the water was spread out. When did the water cover most AREA? In the cup? On the ground?	
3 Look at the cup. It could hold some water. It has VOLUME. Look at the reflection of the saucer. It could not hold water. It has only got A---.	On the ground
4 One difference between a thing having AREA and a thing having VOLUME is that one of them only covers a surface. Which one? The one having AREA The one having VOLUME	AREA
5 Which has Volume? The bottle The blot The shadow	The one having area
6 Which has Volume? The lid The shadow	The bottle
7 Which has Area? (Think hard!) The label The shadow	The lid
8 The bottle can be filled with ink. It has V-----.	Both have
	Volume

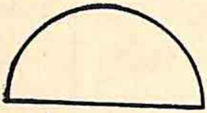
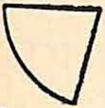
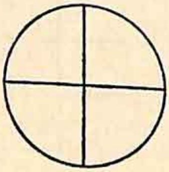
From a Science Programme 'The Atmosphere' for top Juniors and lower Seniors of good average ability.	
77 On a sponge there are thousands of tiny H – – – –.	
78 In a sponge there are thousands of tiny holes. What is in each of these tiny holes if the sponge is dry?	Holes
79 When you squeeze a sponge what happens? A. It gets bigger B. It gets smaller C. It stays the same	Air
80 What happens to the holes in a sponge when it is squeezed? A. They get bigger B. They get smaller C. They stay the same	It gets smaller
81 Suppose that the sponge is soaking wet. What comes out of it when it is squeezed?	B. They get smaller
82 If the sponge is dry when it is squeezed what SUBSTANCE is squeezed out?	Water or some sort of liquid
83 Here is the sponge being squeezed under water. Will the sponge fill with water if the hand lets go?	Air
84 Suppose then, that we squeeze the sponge in the air and then let go. What happens?	Yes, the sponge will get bigger and fill with water
	The sponge will get bigger and fill with air

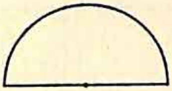
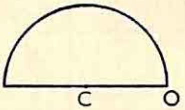
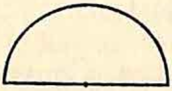
85 What would all the tiny holes be full of after the sponge got bigger?	
86 The sponge acts rather like our LUNGS when it is treated in the way we have described. Remember the sponge when we start to learn about the LUNGS. Try to arrange to get: 1. Half a teacup of sand and water mixed up so that the sand is floating around 2. A jar 3. A piece of blotting paper Fix them up as shown on the next frame.	Air

These are followed later in the programme by:

115 Air is drawn into the ----- when we breathe in.	
116 Here are the lungs in more detail.  A. Windpipe B. Lungs C. Air Branches to lungs (called BRONCHI) At the very end of the air branches inside the lungs we get very, very tiny air-sacs like little balloons. (They are called alveoli, said AL-VEE-OLI.) This drawing is greatly magnified. The air passes into the lungs by the windpipe, then by air branches called the BRONCHI. At the very end of the air passages appear the tiny --- s ---.	Lungs
	AIR-SACS (or Alveoli)

117 When the air sacs (or alveoli) are magnified even more they look like this.  Each of these air sacs is a tiny air space. It is here that the air is brought ready to undergo a change. So the change takes place inside the lungs at the alveoli or a--- ---.	
118 The air from around us does this journey inside us: Through the (1) ---- or the (2) -----. Down the (3) -------- into the two (4) -----. Then the air travels through the air passages called the (5) Bronchi into the tiny (6) ------- or ---s--- where the air undergoes a change.	Air sacs
When you have the results correct copy out all the passage on to the paper you have.	1. Nose 2. Mouth 3. Windpipe 4. Lungs 5. Bronchi 6. Alveoli or air sacs
From a Programme on Shapes for 10–11-year-olds using cut out geometrical shapes.	
72 Take the two green shapes. These you will possibly know about. They are called c------.	
	Circles

73 How many lines does it take to make a circle? One Three Four More	
74 Circles are different sizes, but all the same shape. Draw carefully round a penny. Cut it out. What is the shape?	One
75 Fold it carefully in half. You now have a shape like this  It is called a semi- – – – – – –.	A circle
76 Fold it once more, carefully.  Your shape is like this. Open it up. How many straight lines FROM THE MIDDLE can you see?	Semi-circle (half a circle)
77 Measure from the centre to the outside of each line.  Are they all the same? different? some the same?	Four
	All the same

78 A line from the centre of a circle to the outside is called a RADIUS (said RAY-DI-US). Will each radius of a circle measure the same?	
79 Fold the circle into a semi-circle.  What is the length of the straight line? 1 radius length. 2 radius length. 3 radius length.	Yes
80  We call the distance from the centre *C* to the outside *O* a ------.	2 radius length
81 The word radius can be shown by the letter *r*.  The distance across a circle is $1r$ $2r$ $3r$	Radius
82 When a straight line goes from side to side of a circle and passes exactly through the centre it measures 2—and is called a DIAMETER.	$2r$
	$2r$

83 DIAMETER is said DIE-AM-ET-ER. A DIAMETER = $1r$? $2r$? $3r$?	
84 If a circle has a radius of 2 inches what is its diameter?	$2r$
85 Please get A drawing pin A ruler A pencil A piece of cotton Then think. Draw 3 circles, one having $r = 2$ inches one having diameter of 6 inches one having r of 3 inches	4 inches
	Show your results to teacher

Each of these programmes in its final form enjoins the use of apparatus before, during and after completion of the programme, and one aim is to provide children with the chance of *doing* things on the basis of an acquired insight and skill.

There are other types of programmes, and in several of the standard texts lengthy discussion occurs as to the relative merits of various ways of programming. Perhaps it is sufficient at this point to say that the programme excerpts which the reader has worked through represent a linear or step-by-step approach. A branching programme could be presented in this fashion:

Q. If you observe the difference in the time it takes a thunderclap to reach you after having seen lightning flash, the distance of the storm centre can be calculated.

A. Quite true—page 9
B. Possibly true—page 3

C. Impossible—page 10
D. Unlikely—page 11
Answer by making one choice.

Choice A is made and page 9 is read.

You answered '*Quite* true!'

Your answer would be correct if you were certain of your accurate timing and that there was only one storm in the vicinity. Return and try again.

Choice C is made.

You answered 'impossible'. This is not impossible. If timing is accurate and the particular storm is isolated it should be possible. Return and try again.

Choice B is made.

'Possibly true' was your answer, and in this you were correct. Good. You should know that accurate timing and knowledge that you are dealing with the correct flash are both necessary as well as the quoted detail.

This example is meant to concentrate on the fact that a branching programme anticipates errors and attempts to correct them. A linear programme should be arranged to avoid errors. There are variations of programming techniques in both cases which bring each system nearer to the other; but it will be usual, in this book, to find details given of a modified linear system as the one most suitable for younger pupils.

What can be programmed?

It is not the best of ideas for a teacher to use the same programme at the same time with the whole of a class. There is a good reason for this. A programme accommodates different people at different rates, and if the programmes are of short duration, for example of up to 2½ hours for the average child, then it is much better to use the programmes in small groups of, say, eight at a time, in order to help class organisation. This does not preclude revision in larger groups, but since the major benefit of a programme is in the support it gives to the individual, it is better to consider it in that light, at any rate at this stage.

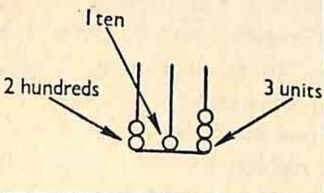
It is possible to produce a programme on a topic that will lead to discussion between members of the class and which needs the reconciliation of more knowledge and advice from the teacher. Such a programme is, for example, that on *The Common Market* (J. Leedham). This is a short programme for 11–13-year-olds. It is intended to convey the idea of international import–export exchange and a knowledge of the countries forming the Common Market, and leads to two 'open questions': 'Should Britain join?' and 'Will there be a common currency one day?' This programme, written in sixty frames, lacks illustration, but could form the basis of a useful approach to geography in Europe by continuing, after the teacher has joined in the discussion, with examples of exchange and foreign currency linked into our proposed 'decimal coinage'. These topics could well be covered, at different times, by the children before they engaged on a suitable project such as a trip to the Continent. The teacher would probably be surprised to find how well rates of exchange and so on are remembered when presented in this way.

Another programme which has had wide use since publication is that on *Nought Difficulty in Number* by R. D. Bews, in the ESA-Tutor series.

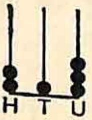
These frames would work through an ESATutor, but the same effect can be achieved if the reader covers up the left-hand column until he has attempted each frame. The programme has already proceeded 12 frames:

Primary Arithmetic Card 3 Set 4

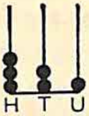
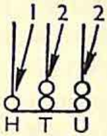
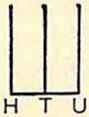
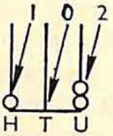
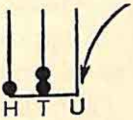
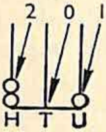
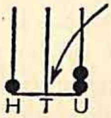
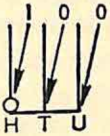
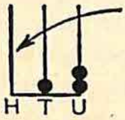
13



13



We use beads on an abacus to show numbers. Here is an abacus showing the number 213. Draw this abacus.

14 1 (321)	14  What number does this abacus show? It is 32 .
15 	15  Draw an abacus and show the number 122 on it, using beads.
16 	16  See that the units wire has no beads at all for the number 120. Now show the number 102 on an abacus.
17 	17  See that the tens have no beads at all for 102. Show the number 201 on an abacus.
18 	18  See that the hundreds have no beads at all for 12. Show the number 100 on an abacus.

Here the author has made use of the abacus illustration for demonstration. Whereas in a textbook there would be one illustration and page of explanation, in the programme there are many illustrations proceeding a step at a time, and never more than a few words of explanation. It is true that if the child has an abacus and a teacher to himself he will make the same or better progress than with the symbols that stand for the real thing. Nevertheless, it is gratifying to see the effect that adequate illustration can have in this respect. Few teachers would have the time, or even the patience, to check and confirm each of forty abacus manipulations.

As modern education evolves it undertakes new tasks. One of these has been the acceptance that something more than arithmetic and computation is needed for our children. The mathematical concept of Sets is attracting much attention, and a programme to instruct children from the age of 9 years old in Set language and the ideas associated with the symbols has been produced in two stages, and has proved quite successful with able children. The point here is that many teachers will need to grasp this totally new concept of symbolisation, and the issue of a programme to present and to teach it is one of the most assured ways of achieving this. The teacher will need to see beyond the bounds of the programme's horizon, but it can ensure that the children have a carefully tested guideway in a new territory.

There will undoubtedly be many revolutionary departures in our school curriculum over the next few years, and teachers will probably become used to relying upon introductory material in programmed form. This may strike many teachers as unusual at first. One could consider programmes in reading in the same light. One of the major difficulties of teaching reading by the Initial Teaching Medium or Pitman's i.t.a. was the cost of instructing teachers. Consequently, the author produced the programmed pack for teacher instruction, and this has economised on time and expense. The application of programme techniques to reading instruction involves the extensive use of audio-visual material as well as printed texts. The interdependent use of carefully prepared material and teacher can achieve outstanding results, and one can fairly expect that retarded readers within the Junior School will be greatly aided and that the teachers of remedial reading will turn increasingly to programmed situations for support. An account of such a situation occurs in Chapter 8.

The following topics are suitable for organisation into programme form and are worth attention before detailed consideration is given as to programme production. Later explanation will suggest the employment of audio-visual programmes as well as of these printed texts linked to small kits. Each programme is thought of as about 100–120 illustrated frames, taking perhaps 2½ hours to complete, and is devised for the younger pupil up to 13 years old. Shorter programmes of 60 frames, which would take 1–1½ hours, are also very useful.

Mathematics

- Remedial number:
    - Recognition of Ordinal number
    - Organisation of Cardinal number
    - Grouping of bases
    - Grouping in ten base
    - Addition in ten base, using abacus
    - Subtraction by equal addition using abacus
    - Subtraction by decomposition using abacus
    - The Nought or Zero difficulty
- Advancing number and mathematics using kits:
    - A simple history of number
    - Recognition of shapes
    - Preliminary ideas on Sets
    - Addition and multiplication
    - Multiplication
    - Multiplication and division
    - Transfer programme to *£.s.d.*
    - Transfer programme to measurement
- Increasing concepts:
    - More on Sets
    - Fractional parts
    - Decimal fractions
    - Equivalence

Simple algebraic notation
The geometry of point and line
Work with shapes
The geometry of the angle
Concepts of area and volume
The language and idea of sets
The slide rule and simple logarithms
Reading graphs

English

Reading programmes in i.t.a.
Reading programmes in traditional alphabet
(These two programmes need separate explanation)
Development of simple sentence
Use of simple punctuation
Experiences in reading skills
Use of reference material
Writing letters
Vocabulary extension and spelling experience
Library catalogues

Other Programme Areas

Map contours and map reading
Telling the time. The 24-hour clock
General quiz programmes on geography
Simple economics
Audio language programmes (e.g. B.B.C. tape-strip)
The history of tools
The history of the wheel
The atmosphere
Elementary hygiene
Simple evolution and anatomy
Resuscitation
Weather forecasting
Simple biology—the study of germination linked with materials
Grouping of animals and plants
Use of microscope
Measuring length with metric and English units

Reading music
Simple astronomy

This list does not by any means exhaust the topics suitable for programming. The list of topics might suggest just what a programme could be expected to do. The Mathematics programmes would attempt to develop the concepts and skills leading to the teacher's employment of them in transfer or problem situations. If the child has secured the idea of groups and bases and then practised in ten base he should be well orientated for transfer to £. *s*. *d*. and measurement problems. The teacher will be the person to direct the transfer, and the employment of programmes should give him much more time per pupil. Of the programmes listed above many have been produced or put under trial by the groups in Leicestershire. A particular difficulty is to provide continuity of material. If only a few copies of a programme are available, demand soon outstrips supply.

7

How to write your programme

Certain ideas and proposals have emerged over the past three years to enable one to offer the following simple outline as an approach to school programming in England.

Most of the instruction about writing programmes has been derived from practices and logical examinations carried on with students who have good verbal abilities. Since these skills are still formative for younger children, it is a sensible idea to use illustrative material to convey concepts. This we have found to be well worth while.

Given this particular emphasis, the usual instructions about programme construction are good guides to prevent much rewriting of frames. They could be put as follows:

1. Determine exactly what the programme is. Is it part of a syllabus? Is it extra material? Is it a new idea?
2. Whom is it for? Can they read it, reason it? Do they need it?
3. Will it be a hindrance in the classroom? Will it easily be torn, get out of order? Can the child be expected to manipulate it?
4. Having reconciled points 1, 2, 3: What will the child be able to DO as the result of the programme? Will he be able to discriminate as a result of the programme—can he apply the new material learned? What level of achievement will he attain? What will he be able to answer?

Having worked this out, it is best to set the aims down in detail developed on the idea of teaching concepts. Here is an example:

A programme on volume

This programme is intended as part of a fourth year Junior School Maths experience.

It is written for 10–12-year-olds with a reading age of about 10·9 years and in an I.Q. above 102 who have worked on the programme on Area.

The programme shall be in booklet form used with a mask.

The test behaviour shall be the child's ability to manipulate material, solid, liquid or gaseous, to show he has a good concept of volume.

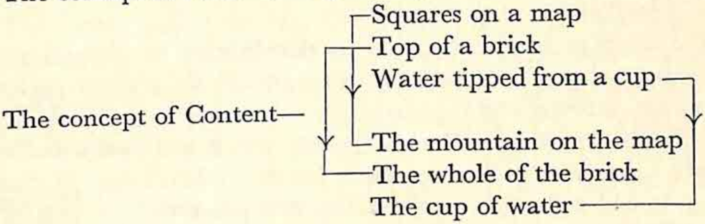
He shall be able to measure the volume of regular figures and calculate the volume of irregular figures by displacement.

He shall be able to answer the questions listed as tests in Schonel's Problems Nos. X, Y, Z.

He shall be able to compare the measurement of volume and quantity in metric and imperial measure.

The concepts to be taught would, therefore, be indicated as:

The concept of Area—*revise pictorially*



The concept of Content—
Squares on a map
Top of a brick
Water tipped from a cup
The mountain on the map
The whole of the brick
The cup of water

The use of cubes—
  Packing cubes into different containers

Concept of third dimension—
  Estimation of cubes by layers

Concept of empty box as having third dimension—
  Removal of cubes
  Discard cubes
  (FADING) (This is explained later).

Lead to concept of plasticity—
  Use clay or plasticine

Displacement of water by irregular objects.

This simple outline approach is given to prepare the reader for more detailed work with programme preparation which follows.

(There are points of divergence in estimates as to the worthwhileness of programmed learning, but on one point unanimity is possible. It is this: the work and research which a teacher puts into a programme increases his capacity to teach.)

The production of the teacher's first programme will call for the following considerations:

1. The child

(*a*) For which particular child will this programme do most good?
(*b*) What will he be able to *do* as a result of the programme?
(*c*) How can progress and interest be sustained?
(*d*) How long should he take?
(*e*) How well can he read?
(*f*) How will his progress be observed?

2. The topic

Is it suitable for presentation in step-by-step procedures with constructed answers? Such topics are usually those which include concept building and repetition.

Should it include 'Review Items' which are really built-in tests, or such items as information panels, which convey information to which the programme refers as it proceeds?

Does it need to include any 'skipping items'? By this means pupils can be directed to skip certain parts of the programme if their performance merits it.

Should any apparatus be employed?

It is proposed to give quite specific direction at this point. Not because this is the only method to produce a programme, but because experience suggests that a definite practical lead enables teachers to blend in their own ideas successfully later on.

First then:

The child

There should be a worthwhile reason for his working a programme rather than a traditional routine. Concentrate on the particular reason for the particular child. Enlarge the field to include other children for whom the programme could be useful. Define their age, reading ability and achievement. *Write these down.*

Anticipate that a first run with a programme should take about three-quarters of an hour and that about forty frames could be attempted in this time by the child.

Determine to make the programme interesting by the use of illustrations or kits if appropriate. Ensure that adequate test situations shall establish whether the child *needs* the programme and whether he has progressed after working with the programme.

The topic

Choose something from the list in Chapter 6 which could be termed remedial; or, alternatively, something in which you are deeply interested and which could extend the able children.

Consider the overall aim. *Write this down.* Be sure it involves the child in active response. Then break down the aim into smaller segments and choose one which you could hope to 'put over' to a child by five minutes' personal explanation. *Write this down.*

You should now have your commencing objectives outlined.

It is at this stage that the reader might be helped with an example of programme construction. Again it is stressed that other patterns exist and examples of alternative developments are included at the end of this chapter.

THE RECOGNITION OF GEOMETRICAL SHAPES

The programme is devised for top Juniors or lower Seniors with a reading age of 10 years approximately and of average ability, I.Q. probably 95–106.

It is designed, with its pre-test and post-test, to take about one hour.

The pupil is not expected to have any specific knowledge of the topic.

As the result of the programme he should be able to recognise, name and construct a square, a rectangle, a triangle and a circle.

He should be able to define a quadrilateral.

He should be able to combine the geometrical shapes into patterns.

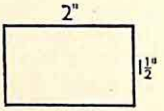
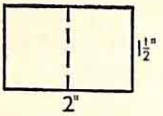
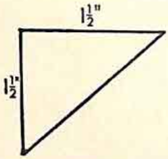
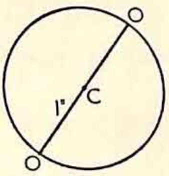
He should be anticipating further geometric patterns by using those he has acquired.

MATERIAL NEEDED: Cardboard shapes of differing size

4 squares	red
4 rectangles	blue
4 triangles	yellow (2 equilateral)
2 circles	green

PRE-TEST. To the child.

Try these questions. Mark your own but be fair.

1		Is this a square? A quadrilateral? A triangle? A circle?	
2		Half of this as dotted could be: a square? a rectangle? a circle? a triangle?	A quadrilateral
3		What shape would two of these make if their long sides were put together?	A rectangle
4		*C* is the centre. *O* is the outside. If *CO* is 1 inch, how long is *OO*?	A square
			2 inches

5 Draw a *rectangle* 1 inch × $4\frac{1}{2}$ inches × 2 inches. Can this be done? How?	
6 What is a right angle?	No, rectangles have opposite sides equal
	An angle in the corner of a square or 'an upright angle'.

5 marks for each.
If you get 20 marks you should not need this programme.
With less than 10 the programme will help.
Between 10 and 15. Ask your teacher.

APPROACH TO PROGRAMME Aim to teach the objectives already outlined.

DIVISION OF AIM:

1. Use shapes to create patterns.
2. Define and recognise a four-sided shape (quadrilateral).
3. Recognise relation between square and sides.
4. Recognise relation between rectangle and sides.
5. Evoke *difference* between rectangle and square.
6. Recognise relation between square and angles.
7. Recognise relation between rectangle and angles.
8. Evoke *similarity* between rectangle and square.
9. Discrimination of parallelogram.
10. Deal with construction of square.
11. Deal with construction of rectangle.
12. Recognise difference between triangle shapes.
13. Evoke three sides to triangle.
14. Indicate division of quadrilaterals into triangles.
15. Evoke *some* triangles have right angle.
16. Deal with construction of equilateral triangle only.
17. By folding cards elicit constancy of r in circle.

18. Confirm $2r = d$.
19. Construct circle given r.

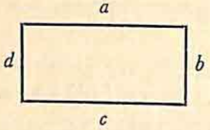
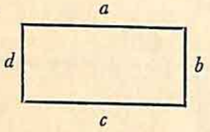
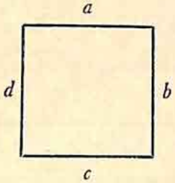
From this breakdown it is assumed that the material in the sections marked 1 to 4 will provide twenty minutes working time. The following frames could be used.

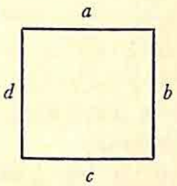
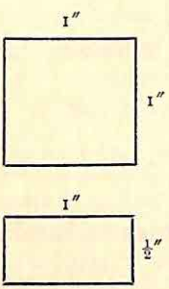
Here is a suggested development for the selected sequence of aims 1–4. The stimuli (questions) are on one side of a postcard. The answers (responses) are on the back.

1. Recognition of relation between sides of square. (*A ruler is required.*)

1 Take out all the shapes. How many are there?	
2 Use all the patterns. Make up as many interesting shapes as you can for about five minutes.	Fourteen
3 Use the yellow cards. How many sides has each card?	Carry on to next frame (question)
4 Count cards with four sides. How many cards?	Three
5 What colours will you be using if you only use four-sided cards?	Eight
6 Use red and blue cards. Are these shapes the same size?	Red and blue
7 If these shapes are different sizes, how is it they are alike? 1. Because they are the same colour. 2. they all have three sides. 3. they all have four sides.	No
	(3) Because they all have four sides

8 Both blue shapes and red shapes have four sides. A special word for four sides is QUADRILATERAL. The QUADRI part stands for four. What would LATERAL stand for?	
9 Write down QUADRILATERAL means - - - - *sides.* It is said: KWOD-RI-LATERAL.	SIDES
10 Remember quadrilateral means four sides. How many quadrilateral shapes are in front of you?	Quadrilateral means four sides
11 All these quadrilaterals are different in size, but each one has - - - - *sides.*	Eight
12 Sort out the reds. Sort out the blues. Use a ruler: measure each side of one red shape. Are they all (1) the same length; (2) different lengths.	Four sides
13 Measure each side of the other reds. Have all the reds got sides the same length on each shape?	(1) The same length
14 Now take the blue shapes. How many are there?	Yes
15 Are these also quadrilaterals?	Four
16 Why are they quadrilaterals?	Yes
	Because they have four sides

17 Take one blue shape. Measure each side. Are they all the *same* length?	
18 Write down the length of each opposite side. Are the lengths the same?	No
19 In the blue shape you have measured there are four sides. Call them the same as in the sketch.  Does $a = b$? $d = c$?	Yes
20  What equal each other?	No
21 Measure all the blue shapes. In each one does $a = c$? $b = d$?	$a = c$ $b = d$
22 Remember the red shapes  Does $a = c$? $b = d$?	Yes
	Yes

23  Does $d = c$? $b = a$?	
24. So with the red shapes each side measures the - - - -	Yes
25 With the blue shapes the – pp – s – te sides measure the same.	Same
26  You probably know the name of the first shape. It is a SQUARE. The second shape is called a RECTANGLE.	Opposite
27 Are the blue shapes you have used squares?	
28 Why are the blue shapes NOT squares?	No
29 Write out a good way of telling someone the difference between a square and a blue rectangle.	Because all their sides are not equal
30 Now you have to learn about the corners of the red and blue shapes. Use all of them to make SQUARE patterns.	Show it to your teacher

This sequence has been kept simple so that the various frames could be demonstrated. As such a programme developed it would be necessary to fade out the colour prompts so that the child could abstract the idea. Objection could be made to the definition of the term QUADRILATERAL so early, but this is deliberate to demonstrate the necessity for eventual generalisation.

It might well prove of help to the reader if various frame sequences are explained so that practice can be gained in their use.

Skip-branch frames

Let us refer back to frame 17 of the programme. Frame 18 could be written:

18 Write down the length of each side.
Now can you write out the difference between a blue and a red shape?
The answer could be:

> 'The red shape has each side the same length.
> The blue shapes have opposite sides equal.
>
> If you got this correct or the idea correct, go on to frame 23.
> If not, carry straight on.'

Fading frames

Sometimes it is necessary to remove cues very gradually as in the following sequence.

Q. Can you build a house? Which word stands for 'put up'?	BUILD
Q. We built a tall b – – – d – – g. Write the word.	BUILDING
Q. The building was b – – – t in three months. Write the word.	BUILT
Q. When we put up a house we – – – – d.	BUILD
Q. The children said they would – – – – – a house in a tree.	BUILD

Here the prompts, both in context and in the number of dashes, have been gradually withdrawn.

Application tests of the teaching would need to occur later.

Panels or kits

The use of the shapes in the examples given should demonstrate the possibilities in this direction. Often a suitable drawing or illustration, properly lettered, will save much time and greatly clarify the programme.

Multichoice or constructed answers

A general presumption in programming circles has been that items calling for *recognition* can best be dealt with by multichoice answers, and items needing *recall* are best covered by constructed type answers. This guide breaks down with young children, and the type of answer to be required is that best indicated by the flow of the programme. Referring once more to our own programme, it can be seen that frames 7 and 12 lend themselves to multichoice answers; indeed, frame 7 could have elicited such replies as 'because they are made of card' had not the form of the question prevented this.

Lead-in frames

Frames 1, 2 and 3 were written for this purpose. The isolation of frame 3 is meant to suggest to the child the fact that shapes have *n* sides, since he will be dealing with four-sided shapes for some time.

Interlocking frames

The need for these will become apparent if this programme is developed. We have established four-sided figures with two different shapes. Now if we propose to put over the idea of right angles the interlocking of the frames will need to occur. For example, one could suggest a red or blue shape should be identified with a corner of a book and the idea of an upright angle established, leading to right angle. Colour shapes could be faded and the child asked to construct a non-right-angled quadrilateral, to lock this section in with the next.

Review frames

To some extent frames 20–23 are of this type, but separate review frames would shortly be needed as a test situation. It is a good idea frequently to leave a certain number of frames without answers in order to ensure attention and progress. It is possible to write suitable frames for such a sequence.

Matrix organisation of programmes

There are variously devised systems of programme production which call for outline rules and examples, defining association and discrimination frames and knitting all into a planned outline. One difficulty is that as the programme develops in outline and in revision it departs from the plan. The claim is made that such a plan saves revision. It may well be that highly symbolised topics would gain from a degree or matrix preparation. Typical of these systems is the Ruleg system of Evans, Glaser and Homme. It assumes that the aims of the programme can be expressed in rules and examples. A list of all the rules is made in logical sequence, and suitable examples are then organised. The rules are next listed by their associations with each other, and a matrix such as that shown is developed where R = Rule, E = Example.

Example of Ruleg Matrix

FRAMES

RULES	1	2	3	4	5	6	7	8	9	10	11
1	E	E	R	E							
2					R	E	E				
3							R	E	D E	E	
4										R	E

R = Rule E = Example D = Discrimination frame (picking out a distinction to illustrate rule)

It is possible for each programme writer to determine his own approach. Occasionally the use of a carefully planned matrix can be of considerable assistance. In *Programmed Learning in Perspective* by Thomas *et al.* (City Publishing Services, 1963), a system of programme construction based on a Ruleg approach is outlined in detail and could serve as a guide to any writer who would prefer the rigidity it might impose. For the purpose of first experience, however, a short programme organised as suggested earlier in the chapter would furnish the beginner with a useful introduction.

Testing and revision of a trial programme

Chapter 3 dealt in some detail with the prospect of wider validation of programmes. The present suggestions deal with the forty to fifty frames on a limited topic (part of a whole) which, having prepared, the programmer wishes to test. Obviously if only one programme has been prepared, and that on cards, then the testing is simple.

A pupil who closely represents the 'target population' for whom the programme was written is given the programme to work through. He should be quietly observed to ensure he tries rather than copies. Examination of the answers will suggest at once which frames need attention, and when this has been confirmed with another three or four appropriate pupils the card can be rephrased or withdrawn. When the programme appears to be working adequately the frames can be typed on to stencils and small booklets duplicated for wider use. It has been found that twenty booklets used in groups of ten at a time give very adequate experience for a first programme.

8

Learning to read by programme

A programme as referred to here means a carefully devised and graded work system aimed to produce a stated skill. Such a programme first poses a very simple problem, the student attempts an answer and is at once informed as to his success. The next problem adds a little to the first one, the answer is checked at once and so the student, by controlled small steps, is led to the final accomplishment of the task.

Reading is only one of the skills which a programmer may have to consider, but it is a very important one. Most programmes depend on some reading ability, and a teacher's very early attention is called to children who for one reason or another have not kept pace with the normal reading level of their contemporaries.

One has to be aware that some children need longer to acquire skills; but the detailed attention necessary in compiling programmes suggests that reading readiness might be a question of *our* incomplete provision for the child rather than *his* failure to be ready. Moreover, children starting *junior* school life with a disposition and ability to read certainly appear to sustain their learning efforts better over the ensuing four years. If a child can learn to read without being forced he is at an advantage.

If we first analyse the attitude of a programme writer considering reading as a skill to be imparted, it would give a fuller meaning to the experiments with machines which we report later.

(*a*) *First* The programmes are for children who cannot read. This is the target population; the aim is to give them the reading skill. Their age can fairly be considered as any within the span seven to twelve years.

(*b*) *Second* Just what is this skill? It is that skill needed to associate certain symbols with certain sounds in order to create meaning.

(*c*) *Third* What abilities has the child to start with? It is assumed he can hear speech and can speak.

(*d*) *Fourth* How does the skill analyse? Into three divisions:

> Visual recognition of the symbol.
> Translation into spoken referent.
> Extraction of meaning.

So here we have four points:

1. A child who cannot read, for various reasons.
2. The child needs to associate sounds with symbols in order to read.
3. The child can talk, he can hear the sounds, the symbols mean nothing.
4. Meaning must be imparted.

The first consideration is to match the sounds to symbols meaningfully. This is easy to say, but depends greatly on the child's prereading experience. However, machines should, and in the few cases where they exist, do, link sound to symbol.

If we take a sound we wish to illustrate meaningfully in a programme we would plan something like this: Take the sound 'I' as in PIG. First the child sees a picture of a pig and hears the word PIG from a tape. He repeats PIG. He sees the picture again and says PIG. This time the letters PIG are revealed to him. Next time picture and PIG occur together; subsequently the picture is left out and the word left in. Variations on this ensure that picture or symbols elicit the sound PIG. The same thing is then done for PIN. It might take twenty pictures or frames of each to ensure the correct response. Now comes the question, hotly debated, as to the recognition of the sound 'I'. By omitting the 'I' in P – G or P – N, the child can be called upon to write it 'I', at the same time giving it its sound value. By careful manipulation a vocabulary can be built up so that the child can start reading. This can be done by a simple machine allied to a tape, and this was the pattern of our early programmes.

Work with reading programmes should provide a fruitful field for experimenters. After all, the goals can be defined exactly, and the subjects are known equally exactly; they cannot read. Nevertheless, the labour of organising programmed schemes is impressive. Here is one account of work under way.

Ten children who had failed to read after two years of attention in school were presented with a programme which started from simple pictures requiring a spoken response into a tape recorder leading to written response in a step-by-step linear machine. The programme led up to simple sentences illustrated by pictures and then on to a prescribed reading scheme. The results for ten children are shown below:

DANIELS AND DIACKS TEST

Average chronological age	Average reading age Sept. 1962	Average reading age Mar. 1963	Gain in 22 weeks
7 yrs 3 mths	5 yrs 1 mth	7 yrs 5 mths	2 yrs 2 mths

For ten other matched children a programmed approach using Sir James Pitman's initial teaching alphabet (a new form of orthography) employed 'listening post' skills. These consist of using taped material broadcast to individual children through headphones and enjoining the use, by the child, of programme cards and programmed responses. The other systems of linear programming such as picture-word response cards were also employed and a typical result is as shown.

DANIELS AND DIACKS TEST

(*using traditional alphabet*)

Average chronological age	Average reading age Sept. 1962	Average reading age Mar. 1963	Gain in 22 weeks
7 yrs 2 mths	5 yrs 1 mth	7 yrs 10 mths	2 yrs 9 mths

Since this gave a result by i.t.a. programme significantly better than the traditional alphabet result, excellent though this was, concentration has since been directed on i.t.a. Several schools have practised 'listening post' skills and developed their own taped system.

The difficulties of this technique are fairly quick to emerge. The vocabulary can become stiff, the work mechanical. The advantage, of course, lies in the patience and one-to-one ratio of machine and child. It has more time than a teacher—and possibly more patience.

A programme, so constructed, needs much illustration and many steps. A typical programme can exist without tapes, but may be weaker because of the omission. Such a programme is *Sullivan Associates Programmed Reading* by Cynthia Dee Buchanan, published by McGraw-Hill. The programme is in booklet form, and the children use masks in order to work out the answer before confirmation. This programme does not employ tape, but relies upon the illustrations to match symbol to sound. Work with this is at present progressing.

A programme for teacher instruction in i.t.a., using plastic masks, was worked out over a year of trial and correction, and this gave a good insight into programme procedures with the i.t.a.

Subsequently tapes have been developed by which the children match sound with symbols on special prepared cards which serve to relieve the teacher of much work with slower children. Nevertheless, the child tends to be a passive performer; he receives rather than creates, and we can now look with advantage to machines which do other things than tell the child what to do.

It always appeared that the principle of reinforcement—the immediate confirmation of success—would be better achieved if the child could do something first. To this end, after discussion with Dr Kind, Schools Medical Officer, Leicestershire, I approached Dr Isherwood of the Department of Ergonomics and Cybernetics at Loughborough University of Technology with the request to create a 'speaking board'.

His solution, now being prototyped, is the creation of alphabet blocks which 'speak' their sounds as positioned, and form words, so that the child, acting either with or without a programme, can create his own sentences, guided by the meaning of the sounds he positions. We have not yet had the apparatus under trial, but it parallels in some measure the work done by Professor Omar Khayyam Moore at Rutgers University in America. Professor Moore points out that his objective was to create an 'autotelic environment' where the child could use a psychologically engineered environment to learn by free access to highly sophisticated machines. The fact that the children learn to read and write from a machine is incidental to some extent.

What happens in Professor Moore's environment is this: young children up to the age of six or seven for no more than half an hour a day have free access to a talking typewriter. This machine is stepped in with high-speed computers and monitoring systems. To the child it presents a standard keyboard. When the key is depressed the character is 'typed' and the sound of the character is spoken. This sound can be varied to some extent. The composition of the 'writing' is at first completely random and haphazard, but by various cues, such as colouring the keyboard and the child's fingernails, a pattern of selection evolves. At this time, usually after some weeks of random access, a task can be monitored to the child, who eventually obtains the necessary responses.

Finally, the child learns to dictate his own material, to play it back and reproduce it in typewritten form quite accurately. As the script is in cursive form the child learns to write by copying what he types on an ordinary blackboard in a special room. The necessary apparatus for the autotelic environment is extremely expensive, and the detail given above is a bare outline. The results which Professor Moore has demonstrated indicate that very young children *can* learn to read and to write most excellently by such a method.

However, such situations exist only where they can receive extensive and expensive research support. Perhaps one other very useful device that might turn out to be very successful is the reading machine shown in the illustration facing page 92.

In this device the card travels from right to left carrying the picture and matching symbols or words. The sound is recorded to match word and picture. The child sees the picture, hears the word and sees the word in any order that the teacher wishes to arrange. The child can also try to say the word himself and hear his result for comparison. Cancellation of all speech tracks is optional. The cards permit of sentences some twelve words long.

So far we have developed fourteen programmes for use with this device. These programmes lead into a prepared and matching reading scheme. The results with traditional alphabet and with i.t.a. are encouraging. With fully developed programmes work for children who have failed to learn to read has become very much more lively and significant. We regard the future of these audio-booklet programmes very hopefully indeed.

An interesting device by Mr Denis Morgan of Swansea, illustrated facing page 93, involves the use of 100 instructional tapes matched to special instructional cards and tasks. The retarded children of secondary age work well on their own with this device, which really is a reading desk with tape recordings, task cards, recording points for the child and much ingenious motivation.

One other machine in the teaching of reading is, of course, the typewriter. The difficulty, besides that of expense, is that of recognising sound–symbol relationship.

Our own research effort may include the use of the group console to teach groups of children rather than individuals. This console presents two simultaneous programmes on slides and can match them with tape recordings. The children, eight in number, have four choices on controls which they hold. Only if the choices are predominantly correct will the programme proceed. We have used this for other subjects, but not yet for reading. A fuller account of the group console is given in the next chapter.

Teaching reading by machine is not a question of 'can it be done?' but rather 'should it be done?' The evidence we have tends to suggest that a machine is a very useful aid. Probably Professor Moore would make a greater claim.

Certainly it should be possible, with the development of devices which allow a child to create speech, and also of sufficient taped programmes, to accelerate the acquisition of reading skills and release the teacher from a large part of the routine. Thus she may more adequately ensure that her work is meaningful and worthwhile.

9

Programmes for the small group

The assumption has so far been made that the use of programmes is for the individual working on his own. It has been fairly suggested that long-continued individual effort could cut off the child from other forms of communication. Some of these are so subtle in terms of the dynamic of the group that they could well become lost to the highly individualised pupil.

The possibility of extending the use of programmes to small groups of children working together has much to commend it to the teacher. It approaches quite closely the several different assignment techniques which he may well have previously employed. Moreover, the cost of equipment shared by a group is a great saving as compared with the same equipment used by an individual. There are several ways in which a programme can be used by a group, but fundamentally they will all depend on a common display. An account of such a display is given by K. Holling in 'The Feedback Classroom', *Programmed Learning* I, 1 May 1964. Holling describes how, at Chesterfield Technical College, he has fitted up a lecture room with eighteen response positions. A slide projector displays multiple-choice questions on material already taught by the instructor. The student has six switches with which to respond. Correct selection gives a green light, a wrong selection a red light. An amber light can be used if the programme calls for a 'don't know' type of answer. Each response is also displayed on a monitor watched by the teacher. It is possible to display the percentage of correct answers as the work proceeds. Essentially Holling is describing an apparatus for giving a test result for a whole group more or less simultaneously, as the test proceeds. Useful as this undoubtedly is, its application with less-sophisticated learning groups might not be particularly helpful because of reading speeds, guessing and so on.'

Other approaches which have been made at classroom level include the following account by Harris in *Teaching Machines and Programmes in Five Leicestershire Primary Schools*, Leicester University and Leicestershire Education Committee booklet, June 1964.

> Working with these programmes emphasises the need for including good and numerous illustrations together with practical discovery work in programmes for the Junior School. A development is being worked upon at the moment and a prototype machine is expected to be in use shortly. This new machine will project programmed film strips to be seen through a small aperture 2½ by 3½ inches by the individual child. In addition to the obvious advantages of enriching programme writing, it will be possible for any filmstrip either to be programmed or to have a programmed commentary written about it. It also facilitates diagrammatic presentation of instructions for practical work.
>
> Three programmes have already been prepared for use in this machine and two are already in filmstrip form. It was thought at one stage in the development, that merging the illustrations with the verbal material would be better than the method outlined above, and the two films were made on this basis. However, they are not wasted because they can be shown by an ordinary projector on to a screen. In fact, this is how the programmes have been presented with a manilla card mounted on the wall in lieu of a screen. An outcome of this method of presentation has been that a projected programme has been used in the group situation, each child having an answer box or programmed booklet which provided immediate reinforcement.
>
> The two programmes in use are both on science, 'The air we breathe' and 'Electricity and simple circuits'. The results with

both programmes are encouraging. The programme on electricity has been in use the longer, and it has been worked by twelve members of the author's class. Also, six group leaders from a fourth year class worked with the programme prior to seeing a TV broadcast on the topic and working through experimental situations. The TV programme was seen by the whole of the class after the group leaders had worked with the film strip programme. It was found that the group leaders had gleaned on their own sufficient interesting material to supplement that of the remainder of the class in a rewarding way.

The time taken by the children to work the above programme varied from 1¼ to 3½ hours, and the average time taken was 1 hour 56 minutes. The average error rate was 3 per cent and an average of 80 per cent correct answers was obtained in the test at the end.

Further experience with groups has been gained by using automatic slide projectors which the children handle by remote control. Three programmes have been successfully used: 'The concept of area and volume', 'Our weather', 'The life cycle of the dragonfly'. These programmes are devised for use by small groups of children, up to six in number. Each child works with a linear booklet which matches the display of illustrations and questions which are displayed by the projector. He completes his individual response, checks if he is correct, joins in discussion if called for, and then one of the group presses the switch for the next slide when all have the correct answer. Sometimes the child is called upon to answer several questions connected with the slide, and the rate of progress is controlled by the slowest responder. However, this is not so great a factor as might be supposed. Within a small group of this nature it is customary to expect some homogeneity, and we have found that if a programme is worked by an individual he will take about 20 per cent less time, but the chances are that his test results will not be quite as good as those obtained in the small group situation. Reference to the article in *Educational Research*[1] on the use of small group procedures with programmes shows the same result. The general finding that work with programmes by small groups is as effective, except for a minor time loss, as work with individually based programmes is also borne out in the work reported by Frye in *Audio Visual Communication Review*, 1963, II, 4, pp. 124–30.

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[1] John Leedham, *Programmed Learning with Small Groups*, Educational Research, February 1965.

Nevertheless, this is all rather tenuous. Many teachers are likely to use slide displays in something resembling programmed order, and it was felt that a more adequate examination of the small group using a programme should be carried out. A large part of research time and detail was devoted to the mounting of the following experimental situation.

A study of the effectiveness of a teaching machine programme used with small groups

From the thirty-two linear programmes produced through the Research Unit the following programme was selected.

THE ATMOSPHERE, THE AIR WE USE AND BREATHE

This programme of 168 frames with pre-tests, group experiments, post-tests and confirming group experiments had undergone validation in ten schools with 172 children. It has had much revision in its eighteen months' production. Illustrated with photographs and diagrams, it calls for the use of apparatus. The age range is top junior, lower secondary with an estimated reading quotient of 103.

The programme attempts to cover:

A simple analysis of the Earth's atmosphere.
The composition of the air.
Simple mammalian evolution and respiration.

The time taken, on average, was 4 hours 45 minutes by a child.

This programme was presented in booklet form to all the children. They performed their work on an individual basis. A pre-test measured their attainment in the subject area before the programme, and a post-test matched with the pre-test examined their progress after completion of the work. This gave record of a varied population of children, each of whom had covered the material by linear programme and each of whom had received no other instruction than the programme.

The pupils were next placed in groups numbering eight or less, corresponding with post-test scores, to work with the group console (described below). They then worked with the group console and group programme, which was organised to restate and re-examine the linear programme as explained later. The average time taken was 69 minutes.

With other groups the revision was achieved by the teachers using the linear programmes as they wished, or by revising the work themselves.

The terminal test for all children was the same and was based on the post-test to the linear programme, but administered about four weeks after the post-test.

The method was designed for:

(*a*) Groups of children who had accomplished all the learning and revision by programme and group machine, with no teacher assistance at all.

(*b*) Groups of children who had accomplished the original learning by linear programme, but who had revisionary assistance from the teacher.

The group console

The electric console (Plate 7) built by Dr Kind, the Schools Medical Officer in the County of Leicester, to J. Leedham's requirements, is a prototype for the full-group console at present being constructed (December 1964). It works as follows:

The control console (B) directs the programme, scores successes and failures, controls 'cheating' and determines the programme procedures, e.g. linear, linear-branching, branching, etc.

The display console (A) carries an automatically advancing paper roll which presents one programme. There is a matching reply roll, display lights for correct/incorrect responses, film-strip support if needed, and an optional manual/automatic control. A slightly differing programme is automatically and simultaneously projected by slides according to the selection made on the eight-button panel. This projected programme is closely linked to the booklet programme and revises the work. The group of children discuss the questions and attempt to select the correct solution.

One child meanwhile works with the complementary paper-roll programme, which directs him to make specific enquiries of the group. When selection of an answer is finally agreed upon the programmes advance only if the answers are correct. Each error is automatically scored, and if three consecutive errors are made the console is arrested and a signal given for teacher aid. During the conduct of the experiments this never occurred. The group can observe its progress by two meter dials which indicate attempt/success ratios.

The final results of the experiment carried out with eighteen groups in nine different schools were as follows:

	Average I.Q.	Average age	Pre-test %	Post-test %
Programme and console	106	11·0 yrs	36	76
Programme and teacher	102	11·5 yrs	37	72

The conclusions from the experiment could be put as follows: There is room to believe that, given equally thorough preparation, it should be possible to instruct and confirm small groups of children in an adequate manner using these techniques and their anticipated improvements. The pattern emerging for future work appears to be that of constructing linear programmes devised to be revised by group programmes. These group programmes might prove to be suitable in booklet form, written as two complementary revisions to be used at the same time. Future work will also be carried out with a considerably more advanced console which compensates for individual responses and adjusts the time allowed. This will also include the presentation of material to be learned by the small group as well as material to be revised.

Work has also been carried on in some areas using branching machines observed by two or more children at a time. They discuss the possible answers. From this they customarily arrive at a better understanding of the material, or so it is reported. When this procedure was tried with able 11-year-old children it was soon possible to observe that the individual performance fell off. The reported detail is too slight to permit of any worthwhile prediction. It is quite certain that the use of group programmes will be developed. They appear to be popular with the children.

This chapter has attempted to look at the problem of presenting programmed material to the small group, and in other than written form. As experience grows with the use of programmes, their illustration by picture, sound or a combination of both will be commonplace. Chapter 15 will attempt to envisage a school of the 1970s which is served by such material.

PART THREE
Programmes in the Secondary School

10

Programming for secondary education

At the outset it is as well to make plain what is meant by 'secondary' education. Our educational system is tending to become diversified, and hitherto accepted classifications are losing meaning, but the remarks here primarily concern the teaching of children from 12 years of age up to 18 plus.

An age range of this size includes a great diversity of physical and mental maturities as well as a wide spread of abilities. What programming techniques are needed to teach effectively at the various levels? Obviously a programme suited to a boy in the upper sixth form of a grammar school is likely to be unintelligible to a junior in the secondary modern school.

The first essential for a programme aimed at any population is that it must be comprehensible to that population. The language used should be geared to the reading ability of the group, the size of step must be appropriate to their intelligence range. Equally, any preknowledge assumed in the programme must be possessed by all who are to make use of it. It would be a waste of time giving a programme covering only simultaneous equations to a pupil who knew nothing of simple equations. This is an obvious error, but many such potential pitfalls are more subtle, and a conscious effort needs to be made in order to avoid them.

For these and other reasons it surely seems essential that programmes should be written by teachers. Chemistry programmes by Chemistry teachers, History programmes by History teachers and so on. Furthermore, these teachers must be familiar with teaching their subject at the level the programme is intended for. There have been some abysmal attempts by university lecturers to write programmes for schoolchildren, whom they have never had the experience of teaching. Although such experts may well have something to contribute to lower-level programmes, it is better that the actual programming be done by the man on the job.

A view often propounded in the past, especially by psychologists, was that successful programmes could only be written by psychologists, with possibly a 'subject-matter expert' in attendance. The justification for this attitude was the behaviourist theory, from which programmed learning allegedly sprang. We now recognise that there is no accepted theory of programming, at least for the present, and similarly there is no necessity for programmes to be written by psychologists.

In general, we may say that the success or failure of a programme will depend to a high degree on the motivation of the pupil. Motivation can be a very ephemeral quantity, easily reduced in value by any frustration that may be engendered by the teaching medium. So long as all goes well in a programme, there is a good chance that a fair degree of motivation will operate, but this state of affairs can quickly change if the programmer makes certain mistakes. Among these is the one, mentioned above, of requiring knowledge not in fact possessed by the student.

Another mistake which occurs is hard to circumvent. It arises when the pupil makes a response which is correct, but not allowed for by the programmer, or alternatively, makes a response which is incorrect, but the student cannot see why. At least one study reports that pupils quickly became truculent when they made responses which were correct but not included in those given by the programmer. To avoid frustration from such sources as these one must initially pay great attention to the wording of frames; at all costs avoid slipshod phraseology which permits a multitude of correct answers. A further step is to make clear to all students that they should consult the instructor in the event of any query or difficulty.

It is interesting to note that good programmes are more likely than bad ones to cause this type of frustration. One is irritated by the noise from the electric clock in a Rolls-Royce, whereas a rattling door in a popular car may be accepted with resignation. Thus, it behoves the programmer to be always on guard, no matter how great his experience.

A useful scheme adopted in some quarters, and deserving wider use, is to involve the pupil more deeply in improving of the programme. This is effected by issuing answer sheets to be filled in as shown below.

Frame No.	Answer	√ or x	Comments	Suggestions
1	Current	x	Question not clear	Reword question

The first three columns are invaluable when the programme is being revised (note that working is done on separate sheets, only the final answer is called for in column 2), and the last two serve a dual function. They allow the pupil to work off some of his spleen if he feels he has been ill-used, and occasionally comments and suggestions will throw valuable light on certain inadequacies of the programme. It is in addition a salutary exercise for the programmer to be made aware of subjective opinions on his handiwork. Naturally comments and suggestions are unlikely to be forthcoming if the teacher is quick to take umbrage, and this brings us to a further aspect of motivation.

A programme is essentially a permissive medium of instruction. Students are reported as saying how much they appreciate being able to work without the teacher 'breathing down their neck all the time'; it is perhaps for many of them an unusual experience to work at their own speed, removed from external pressure. Another facet of this permissiveness is the accepted standard that any difficulty experienced by a pupil is the fault of the programme not of the pupil. This last point is worth great emphasis;

however the critics may castigate programmed learning, the movement surely possesses stature by virtue of its shouldering the responsibility for *lack* of learning, rather than pushing off the blame on to the unfortunate learner.

We have then in programming a teaching method which largely leaves to the individual learner the responsibility for his progress. Assuming that the programmer has practised his art effectively, the programme is presented as a vehicle for learning and the student can use the vehicle as he chooses. It is therefore obvious that every available means must be utilised to keep motivation high. To recapitulate: we must prevent frustration from any cause, and should involve the student in the programme as best we can.

It should go without saying that at all stages instructions must be explicit. If responses are to be written, make sure this is plainly stated; if written responses are optional, ensure that this is clearly understood. Occasionally a student may be required to show up answers—do not leave him to search for the missing answers, tell him in the text to bring them to you. A word of warning here: avoid specific instructions given in advance, such as, 'When you get to Frame 153, go and examine the specimens on the bench at the rear.' If such a procedure forms an integral part of the programme it is worth printing or writing in, do not expect a student to bear such information in mind while he works Frames 1–152.

A demon which is always lying in wait for the writer of programmes is *boredom*—on the part of the pupil not the programmer. Anyone who browses through a wide range of published programmes will be struck by the high degree of built-in boredom. It is, of course, quite likely that we attach too much importance to this: a majority of children at secondary level expect to be bored at school. Their interests lie largely elsewhere, especially during the years of adolescence, and it is an exceptional teacher who can invest, for example, Latin grammar with much interest on a summer afternoon for a class of 14-year-olds. None the less, we must surely strive to produce programmes which hold the interest as much as possible, and we can bring several techniques to our aid here.

The old adage, 'A change is as good as a rest', succinctly expresses a proven scientific fact which the programmer can easily exploit. A change can be given by various means, to some extent dependent on the subject matter; at suitable points the programme may give instructions, for example, to:

(*a*) Go to the library and read pages so-and-so from such-and-such a book.
(*b*) Go to the library and copy a certain diagram from a book.
(*c*) Go to the laboratory and perform a certain experiment.
(*d*) Visit the hedge-bottom at the back of the canteen and obtain a slug for subsequent examination.
(*e*) Work the following test and hand in your answers.
(*f*) Go to the tape-recorder at the back of the room and listen (via earphones) to the recording.

Such diversions, quite apart from any educational benefit, serve as invaluable breaks from monotony. Similarly, it is a good thing to vary the length and type of frame and of required response. Other than the usual brief answer and the occasional essay discussed elsewhere, one can call for answers in the form of diagrams or drawings; the labelling of maps or diagrams is also a useful response, as is calling for comments on diagrammatic material. Variations of this nature will occur to all teachers, the details differing from subject to subject.

The occasional open-ended (no answers given) test serves several functions, these may be summarised as:

1. A check on the progress of the pupil.
2. A powerful incentive to concentration in the body of the programme.
3. A motivating force in so far as such tests clearly reveal to the pupil that he is making good progress.
4. A change or diversion as previously noticed.

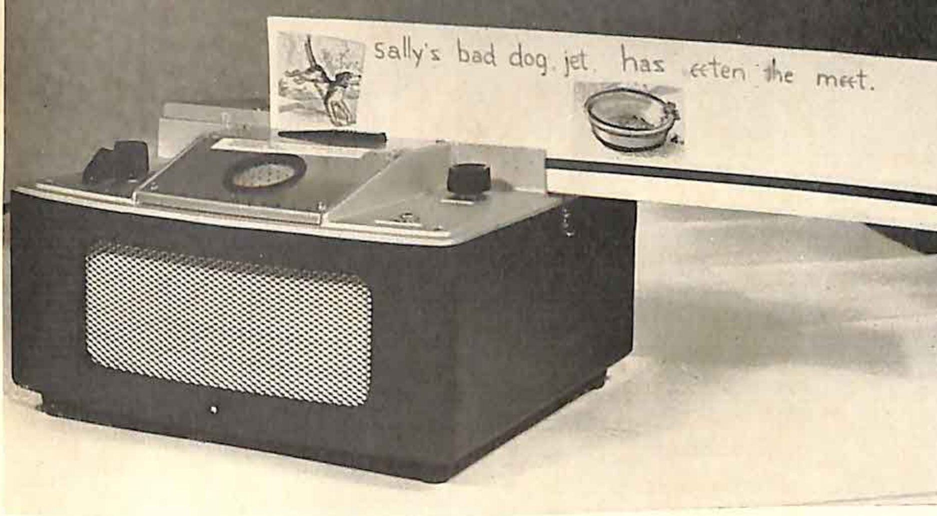
It is advisable to keep a record for each pupil in which is noted both his score in tests and the time when he showed them up. This gives a ready check on the class as a whole, and may reveal areas of the programme which for some reason take too long a time, or are in need of revision because they are not teaching effectively. Such tests are also valuable where programmes are being given as homework, as no matter how stimulating the programme may be, there can be a tendency in the absence of supervision to copy responses in order to get the work done quickly.

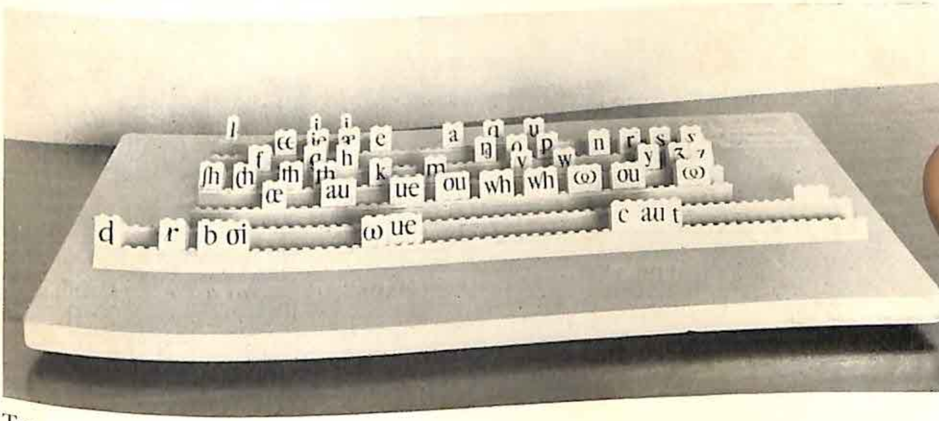
The trend has so far been for a majority of programmes to be written in the fields of science and mathematics. This is due in part to the greater ease of programming such formal subjects, and perhaps more particularly because of large classes and staff shortages in these areas. This last observation is certainly applicable to secondary schools in this country, and it is likely that this state of affairs will continue. Sufficient experience has been gained in the programming of scientific and mathematical material for a substantial body of knowledge to be built up, consequently the topic is dealt with in a separate chapter.

A plea is made elsewhere in this volume for consideration to be given to formal training in logical thought. This is specifically pertinent to secondary education, for only at this stage has the child developed the reasoning powers necessary for such formal training. The present author, for one, would like to see logic appearing in the school timetable as a regular subject.

This is at present rendered extremely difficult if for no other reason than an absence of logicians among school staffs. However, this is not really an insuperable obstacle, because a suitably written series of programmes could provide a substantial amount of instruction in the subject. If the result was that pupils became more logical than their teachers, so much the worse for the teachers! However, the purpose of this digression is not to grind the author's personal axe, but to illustrate how the use of programmes can broaden the curriculum of a school.

It seems reasonable that children should be able to pursue any worthwhile study at school, but this cannot be done, because only in large schools can a very wide range of subjects be offered. For example, in a small country grammar school every year one or two students might wish to study geology or economics or some other mildly esoteric subject. It is, however, not feasible to engage specialist staff in these subjects because of the very small numbers requiring such teaching, so the embryo geologist or



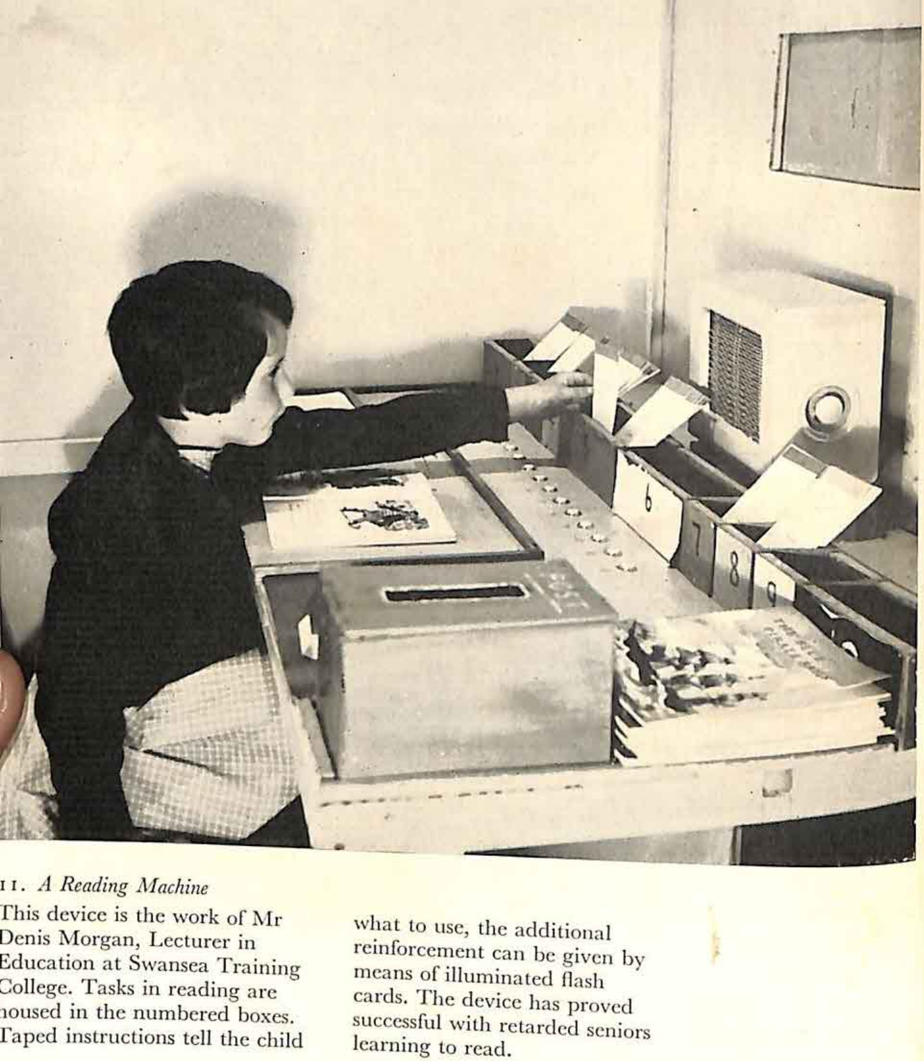


Top
9. *The Reading Master*

This device was first tried out in this country by J. F. Leedham and programmes as shown developed for it. The card carries pictures and words. Tape enables the teachers to identify the pictures and words and the child to hear the teacher as often as he needs, and to hear his own voice in the same situation as often as he needs.

10. *The Speech Board*

This prototype serves to demonstrate the idea implicit in the work of Dr Isherwood of the College of Advanced Technology, Department of Ergonomics and Cybernetics, Loughborough, in co-operation with J. F. Leedham. The board, which is here shown programmed in 'ita', permits the child to position characters (phonemes) and to hear them sound in relation to each other. The work is not yet fully implemented.



11. *A Reading Machine*

This device is the work of Mr Denis Morgan, Lecturer in Education at Swansea Training College. Tasks in reading are housed in the numbered boxes. Taped instructions tell the child what to use, the additional reinforcement can be given by means of illuminated flash cards. The device has proved successful with retarded seniors learning to read.

economist is shunted off into a different discipline. Occasionally the local Technical College can help out, but in general the pupils are denied their wishes. This situation changes drastically if suitable programmes are available; although a programme in isolation is not an ideal instructional medium, it is very much better than nothing. By having such programmes on hand almost every choice of subject can be catered for, thus equalising to some degree the opportunities we offer to children in every school.

Quite apart from the use of programmes to extend the courses available in a school, there are other occasions when the medium has special advantages to offer. One of these arises with children who for various reasons have missed a number of lessons, perhaps through sickness or perhaps because of changing schools. Of course a child who is away sick may be in no condition to work at home, either on a programme or any other instructional medium, but a different state of affairs occurs on the return to school. The child is now ready to work, but is unable to do so effectively because of the gap in his knowledge. The conventional answer to this hiatus is that the work must be 'made up', and this is done with varying success. Clearly, for many if not most pupils this 'making up' is very cursory. The frequent result is a mental 'blind spot' which will probably persist for ever.

If a course is programmed, illness becomes of secondary importance, for it results only in loss of time. Even this loss of time can be eliminated if it is thought worth while for the programme to be taken home for 'making up'. This would still be 'making up', but with the difference that no difficulty should be experienced in doing this work. If, on the other hand, a child misses part of a non-programmed course it would surely be a great boon to have a small stock of programmes available for just such exigencies.

When a child changes schools it is apt to be a very serious matter. Teachers in this country are naturally proud of the individual discretion they possess in planning courses. Although the overall syllabus is often laid down by external considerations, or by authority, most teachers are substantially free to manipulate their own courses within the prescribed area. However, it seems that our society is becoming ever more mobile, and perhaps the time is not far off when the possibility of applying a more uniform curriculum must be considered. At present grave difficulties are encountered by a pupil transferring to a different school.

Let me pose this type of problem in an extreme form: imagine a boy who has left a school after his third year, and during that year his Physics course dealt with heat, light and sound only. He enters his new school to find that the fourth-year Physics course is again to be heat, light and sound. Obviously he is going to miss out large areas of the Physics syllabus unless some solution can be found. Maybe at this point some readers are going to say that the problem is artificial—such an *impasse* could not in practice occur. But in fact this does happen—and not infrequently, and as to finding a solution—there is no solution. But there might be a solution, given goodwill on the part of the teacher and a stock of programmes. One may not like the idea of a boy spending the bulk of the Physics course working away by himself at a programme. No one would pretend that this is the ideal way to study Physics or any other subject, but the only alternative is to standardise Physics courses throughout the country.

It occasionally happens that a particularly bright or diligent pupil is well placed to study some advanced or difficult topic which is not suited to the entire class. There is no difficulty if the teacher's timetable is a generous one, but often there is not enough time for proper attention to be paid to the student. This is perhaps most likely to occur in the sixth form, where the third- and second-year sixths may well meet together. This would seem an excellent outlet for programmes, and it is quite probable that programmes prepared for use in universities would be beneficial in this connection.

Apart, then, from making use of programmes in routine teaching, there are several other circumstances where the medium can be valuable. It is worth noting that for such supplementary usage there is no need to purchase full sets of programmes, only a few are needed to perform the appropriate functions.

It is reasonable to suppose that not one teacher in fifty normally turns his hand to writing textbooks or other forms of literature.

Thus, many writers of programmes are by no means experienced authors; this will perhaps not inhibit the production of useful programmes, but it does mean the products may suffer from certain faults of construction. I refer here not so much to faults in programming technique but to more general deficiencies, found in any form of the written word. Particularly relevant to the auto-instructional field is the necessity for the level of language used to be appropriate to the pupil. In a conventional lesson it does not matter that an occasional word is not understood, or a particular sentence structure lacking in sense, but such errors loom large in a programme where we hope to make every frame meaningful. It may be advisable to consult the English teacher, and perhaps persuade him to read the draft programme before presenting it to a class. When in doubt, strive to make things as straightforward as possible. It is probably better to sacrifice some writing style if such a sacrifice saves a frame from ambiguity.

The different modes of responding to programmes are considered in Chapter 14, where it is seen that controversy exists over what type of *answers* should be required. We also discuss elsewhere the possibility of calling for occasional essay-type responses, but it is perhaps appropriate here to consider the question of *working*. At the secondary level of education it will frequently arise that several stages of working are necessary before the required answer is achieved. It is, of course, possible to include some or all of this working in a given frame or frames; a common device is to withdraw the amount of working shown gradually in successive frames, thus weaning the student. It will have to be decided by the individual teacher whether his pupils must make each of their responses completely grammatical, or whether isolated fragments can be written down. Whichever method is adopted, instructions should be explicit, as also in other topics previously mentioned.

In conclusion to this section we can say that the problems of writing programmes for secondary schoolchildren differ in degree rather than in kind from those encountered at other levels. Provided programmes are written by teachers experienced in dealing with the type of child aimed at, no serious difficulty is likely to occur.

11

Writing a programme

The author believes that good programmers, like good authors, will with growing experience develop their own style of writing and their own approach to programme construction. None the less, it will often be useful for the beginner to have a scheme suggested to him, in order that he may make a reasonable start. The following plan is merely a tentative set of instructions to be discarded if experience indicates a method more suitable to the individual programmer.

1. Decide on your topic

This appears rudimentary, but in practice many teacher programmers tend to concentrate on some topic that they like and already teach well. If this is the case, why bother to write the programme? Far better, programme some course which you do not like teaching, or even more promising, a topic which your pupils find difficult. In all probability every teacher can think of several subject areas which fulfil both these requirements.

2. State your requirements

List very fully what you expect your pupils to be able to do when they have completed the programme. The best policy is to write a comprehensive 'final examination'. Not the usual type of examination which tests only a small sample of the work done, but rather one which satisfies you that a mark of 100 per cent would represent absolute mastery of everything in the course.

In general, you will never administer this examination to the students; the purpose of writing it is to enable you to bear in mind what you are trying to teach. Without such a clear objective the programme may prove very disappointing when you try it out.

3. *Brief syllabus*

At this stage construct a list of the main topics to form the programmed course. These can profitably be written out on cards, the point of this being that from your experience as a teacher you will be able to think out the most appropriate logical order of material for your pupils. The use of cards facilitates any rearrangement. It may be noted in passing that subsequent events could require the order to be amended.

4. *Detailed plan*

For each syllabus card prepare a more detailed schedule of teaching material. This will include examples, illustrative matter, rules, definitions and so on. Again, write each separate item on a card—preferably of a different colour from the syllabus cards.

Experience and thought will once more suggest the best order for the material to be presented.

5. *Pre-test and post-test*

With pupils of known background a pre-test is largely unnecessary. Its purpose is to establish that any pupil embarking on the programme possesses the knowledge-level at which the programme begins. If you propose sending your work far afield it will be a wise policy to construct such a test to preface the actual programme.

The post-test follows on completion of the programme, and is intended to see how well learning has proceeded. It will not be exhaustive, but will sample the programmed material in accordance with usual practice. The post-test is sometimes administered to a student before he works the programme in order to determine whether he already knows the subject matter, and hence does not need the programme.

6. Writing the frames

The instructions given so far correspond to teaching someone to swim on dry land. But no matter how carefully the student is schooled in the appropriate arm, leg and breathing motions, this is not the same thing as being able to swim. The stage has now been reached in writing the programme where the writer must jump in at the deep end and see how he performs. It is not possible to give detailed instructions for writing frames—one carries out the work as carefully as possible, hoping for the best.

Early efforts at frame-writing are often stilted and boring, but practice generally brings better style, although the spectre of boredom still stalks the sequences of large numbers of published programmes. There is no doubt that to most people fluency comes with experience, but it is as well to put in a word of warning here: if you have never been good at expressing yourself in writing, or if your grammar is poor, then you will find difficulty in writing reasonable programmes. Above all else, a programme is a vehicle for *communication*; the best programmes are likely to be written by people having a definite ability to communicate via the written word.

Although it is not proposed to give rules for frame-writing, there are a number of guidelines which may assist.

(*a*) *Be unambiguous:* put yourself in the position of the learner, can he misinterpret what you have written?

(*b*) *Be brief:* this should not be taken too literally; some authorities have seen fit to dictate a maximum number of words which should appear in a frame, but this seems to be superficial. Of more importance is the firm resolve to move only one step at a time. If your programme calls for the student to handle n concepts at one and the same time, first introduce the concepts singly and then gradually write frames in which $2, 3, \ldots n$, concepts are brought together. At all costs strive to avoid killing two birds with (as it were) one frame.

(*c*) *Be simple:* if there is more than one way of presenting something, choose the simplest. Obviously this goes by the board if your object is to teach complex methods, but in general choose the most straightforward way of meeting your aims.

(*d*) *Be aware of reading ability:* if you are writing a programme aimed at teaching the use of a dictionary, then you may use unfamiliar words or phraseology. Otherwise such a practice should be avoided—a programme should flow smoothly without the pupil having to enquire further into the meaning of the language you have used.

It can be seen that much of what is said above applies to teaching generally and to writing generally, as well as to the construction of programmes. This is once again a demonstration that all these skills are closely tied up with the subject of *communication.* Any successful communication technique can supply valuable ideas for the teacher, and such fields as advertising, the popular press and television have much to offer the programmer if he looks carefully.

7. Validation

This heading can mean anything or nothing according to interpretation. Here it is used to describe the process of evolution by which a programme grows from being merely the brain-child of one man into a genuine teaching medium with performance proved by the supreme arbiters—its intended recipients.

Authorities disagree over how much validation is needed; certainly if you wish one of your programmes to be published it may have to have very wide trials. However, we will assume you are writing for use in your own school, or better still for use in your own and a few neighbouring schools. In this case two trials will probably suffice, and these are described below.

FIRST TRIAL

Prepare one fair copy (preferably typewritten) of the programme on suitably sized cards—one frame to a card. The correct responses to each frame should be found on its reverse side, *upside-down.* Next it is convenient to punch two holes in the top of each card (an electric drill is a useful, albeit hazardous tool for doing this *en masse*), and thread a loop of string through each hole. The end product of this looks similar to a set of cloth samples, and can be conveniently worked through by a pupil. As he responds to each frame he flips the card over, thus revealing the correct answer, now the right way up.

The number of pupils who work through this first draft is a matter of choice and availability; about four is probably enough. Try to avoid using bright pupils: if possible select from the lower end of the intelligence spectrum of those for whom the programme is intended. If the programme is a long one, time can be saved by binding it in sections and starting a second student as soon as the first one has completed the initial section.

Do not have responses written down haphazardly on scrap paper: issue sheets such as those described on page 89. This will make the task of revision much simpler. When you have collected in all the response sheets, together with the post-test answers from each pupil, you are ready to begin the first stage of improving your programme.

First—the post-test results. Did the programme teach what it set out to—at least on those topics covered by the test? If so, well and good; if not you will have to rewrite some sections. If the test results are very poor it may be necessary to give a second, wider test in order to see if any part of the programme is worth keeping. Things are unlikely to be as bad as this if your groundwork was properly prepared.

Assuming the test results to be reasonable (and you must be the judge of what is reasonable), the procedure now is to go through the programme frame by frame in the light of your pupils' responses. Any frame which all students got correct can stand (unless mistakes in the post-test or in later frames indicate a weakness at this point), and obviously the odd error due to carelessness can safely be ignored. Greatest attention should be focused on those responses which demonstrate a fundamental lack of understanding. As in so many other aspects of programming, the experienced teacher is in the best position to revise his programme adequately.

One of the usual results of revision is that the programme gets longer: there is an inherent streak of laziness in most of us which has the effect of making us condense our programmes.

Fortunately our pupils quickly put us on the right track when we analyse their responses.

Quite possibly you will end up rewriting half your frames and inserting half as many again completely new ones. Do not be discouraged! Your programme is evolving, and it is best to regard the first draft as merely one stage in the process. Revision and rewriting are just as important tasks as was the original production.

SECOND TRIAL

Your revised programme must now be prepared in suitable form for administration to a larger number of pupils. A class of about thirty is a convenient size, and their ability level should be commensurate with the population the programme was written for. Wax or spirit duplication on foolscap paper is usually convenient with a down-the-page format as shown below:

	FRAME 1
CORRECT RESPONSE TO FRAME 1	FRAME 2
CORRECT RESPONSE TO FRAME 2	FRAME 3
CORRECT RESPONSE TO FRAME 3	FRAME 4
CORRECT RESPONSE TO FRAME 4	FRAME 5
CORRECT RESPONSE TO FRAME 5	FRAME 6

There is little point in stapling the sheets together: six or so sheets will probably cover a period's work, and this is not an unwieldy quantity of paper. It is advisable to issue each student with a piece of stiff card (say about 8 × 10 inches) to cover up responses and frames he has not yet reached.

When results are in you will again have to examine each frame in accordance with the responses obtained. This time you will be in a position to work in a more statistical way. Total the correct responses for each frame and calculate this as a percentage. Any frame giving a figure of 90 per cent or higher is almost certainly in order apart from the reservation below. Any frame coming much under this figure is in need of further revision. These guides must be treated with caution because later parts of the programme, or post-test results, may indicate that although certain frames are being answered correctly they are not teaching very much. In this event more drastic rewriting will be needed.

It should be noted that your post-test is aimed at pupils who have worked through the twice revised version, and you should not be downhearted if results are less encouraging with the first and second drafts. If, say, the first version produced brilliant test results there are two possible conclusions: either you are a natural-born programmer of genius or your test is too easy!

Following this second trial and subsequent revision, the programme can be regarded as ready for your own general use. You will require some more convenient and durable method of holding the programme together. Quarto duplicated sheets held in cheap ring-binders have proved useful, especially if voluntary labour can be enlisted for sticking linen circlets round the punch-holes on each sheet. Unless economy prescribes otherwise, it is greatly preferable to duplicate on one side of the paper only—any possibility of distraction should be eliminated.

Conclusion

Programming is an arduous and time-consuming task, many more people start writing programmes than finish them. However, speed and fluency come with practice, and the fiftieth programme you produce will not only be better than the first, it will take you much less time, size for size. Nor will your early programmes prove useless: many teachers have found that their first efforts, although lacking the *finesse* of later work, can often play a useful part in the classroom.

One is often asked how long it takes to write a programme, and how fast pupils will work through the programme. No hard-and-fast answers can be given to these questions, it all depends on the nature of the subject matter, the ability and level of the pupils, the personality of the programmer and a host of other factors. It is fairly generally accepted that sixty frames per hour represents the order of magnitude of the rate at which a programme can be worked by an average pupil, but this can be no more than a rough guide. So far as the programmer's rate of working is concerned, the author is prepared to say that under excellent working conditions (especially fairly long uninterrupted sessions) an experienced programmer should be able to produce one hour's work for his pupils for about eight hours' work himself. This time, of course, includes that spent on the two revisions, though not any time spent in secretarial work (typing, duplicating, sorting, etc.). An implicit assumption is that the programmer has taught the subject matter a good deal and that the programme is mainly verbal or mathematical material.

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Mathematics and allied subjects

A large number of published programmes lie in the field of mathematics. It seems likely that the reasons for this are twofold:

1. The subject lends itself readily to a programming approach.
2. There is a great need for improved methods of teaching mathematics, especially bearing in mind the chronic shortage of specialist teachers.

At secondary level conventional teaching in mathematical topics already bears a superficial resemblance to programming. The teacher commonly gives a more or less cursory introduction to new material, but the bulk of the pupils' time is spent in working examples. It is worth noting that the clever pupil works vast quantities of such examples while his less able fellow struggles to get even one or two correct. How much better it would be if the most practice went to the boy or girl who needed it.

It is said above that there is some similarity between programming and the usual approach in mathematics. This is true in so far as the examples to be worked are *graded*; unfortunately the grading in textbooks is generally imprecise and there is virtually no lead-in to the first example on the list. How can we improve this arrangement? There are several ways in which proper programming can help.

Let us assume that the teacher introduces the new material. Parts of this introduction will probably be repeated, but in different form, in the programme. Then we come to the practice:

the first examples must make miniscule advances on what the pupil already knows. As he proceeds he is given ample practice at every variation, and each single new feature is introduced by itself and very gently.

The advantages accruing from such a programmed approach are:

1. The least able child should be capable of proceeding and thus obtaining the practice and confidence he so desperately needs.
2. Should a pupil for any reason get stuck, the exact nature of his difficulty is pin-pointed by the stage of the programme he has reached.
3. By some such means as 'skipping' described in Chapter 14 the clever student can by-pass boring and unnecessary practice.
4. Each response is immediately checked against the correct answer. This is extremely helpful to the learner and in addition relieves the teacher of much marking.

No doubt the reader will be able to think of other items to add to this list. He should also ask himself, 'Is there anything to put on the debit side?' Only one thing comes easily to mind: the required programmes are not yet in existence. All is not lost because of such a basic difficulty; slowly but surely programmes on Mathematics are being published, and it will not be many years before a wide range is available. But there is a further point of fundamental importance: programmes of the type outlined above are probably far easier to write than any other. Any experienced Mathematics teacher could soon train himself in their production, and probably produce them at a rapid rate. The ideal situation would be for a group of teachers to get together and farm the syllabus out between them. In this way impressive numbers of programmes could be obtained within a year or so.

Some practical considerations

In writing a mathematics programme it must be remembered that by grading the work carefully pupils will on average spend much more time actually working rather than time-wasting. Consequently there is no need to be apprehensive if the programme appears to incorporate many more exercises than most students would usually complete. The actual number of repetitions at each stage will be initially based on the programme author's experience, to be modified according to results obtained from subsequent trials.

It is vital to change the type of example only very slowly, and to treat each example from every possible direction. Consider a programme on simple equations: at some stage one would expect to see frames like the following:

$$x + 2 = 5$$
$$\therefore x = 5 - ?$$

$$x + 4 = 9$$
$$\therefore x = 9 - ?$$

---

and so on, repeated as necessary. In addition we should expect to find several other types of frame in this section, e.g.

$$x + 1 = 3$$
$$\therefore x = ? - 1$$

---

and

$$x + 3 = 4$$
$$\therefore ? = 4 - 3$$

---

and

$$x + 5 = 7$$
$$\therefore x = ? - ?$$

Multiple practice must be the keynote, and the practice has to be carefully graded and should approach the problems from all possible directions.

Model answers

It is a common feature of textbooks to supply worked solutions to a few problems. Unfortunately for the pupil, when he turns to the examples at the end of the chapter he finds these model answers to be of little use because most of the examples are of a different type. We seem to regard it as particularly heinous for anyone to solve a problem while he has access to a worked example of similar type. Contrast this with the usual methods of learning to play golf, or pronouncing a foreign language. Pupils learn to say 'oui' correctly by listening to their teacher say the word; he does not pronounce 'vous' for them and then demand that they respond with 'oui' in a French accent.

The technique of worked examples is a very useful one, especially when dealing with more complex material involving the use of several subordinate skills. Suppose in a programme we have led up to the solution of simultaneous equations by the method of elimination. At this stage we may well put in a panel (i.e. a display not forming part of the sequence of frames) which gives a worked example, e.g.:

Panel J.

PROBLEM: Solve the equations $2x + y = 5$
$3x + 2y = 8$

SOLUTION: $2x + y = 5$ . . . . (1)
$3x + 2y = 8$ . . . . (2)

Multiply equation (1) by 2:
$4x + 2y = 10$ . . . . . . (3)

Take equation (2) from equation (3)
$x = 2$

Substitute this value for x in equation (1)

$$2 \times 2 + y = 5$$
$$4 + y = 5$$
$$y = 5 - 4$$
$$\underline{y = 1}$$

i.e. $\underline{x = 2,\ y = 1.}$

Now the frame first referring to this panel may read:

---

94 Turn to *Panel J*, which shows you how two simultaneous equations can be solved. Read the panel carefully and refer to it for Frames 94–110.

(Turn to next frame.)

Then might follow a series of questions aimed at focusing attention on the panel and eliciting understanding of it. Some of these may be very rudimentary, both to give confidence and to enhance perception of the overall solution, e.g.

95 Write down the equations which are to be solved.

96 Write down equation (3).

97 Equation (3) is obtained by multiplying equation (1) by ——.

98 What value is obtained for x?

99 Having found x, the first step in finding y is to substitute —— for —— in equation (1).

Other frames will give more searching questions enquiring why certain procedures have been adopted, but it is first necessary to set the scene in order to translate in the pupil's mind an only partially meaningful jumble of words and symbols into the entity the Panel appears to the teacher.

Finally, we come to:

110 Using *Panel J* as a model answer, solve the equations

$$2x + y = 8$$
$$3x + 2y = 13$$

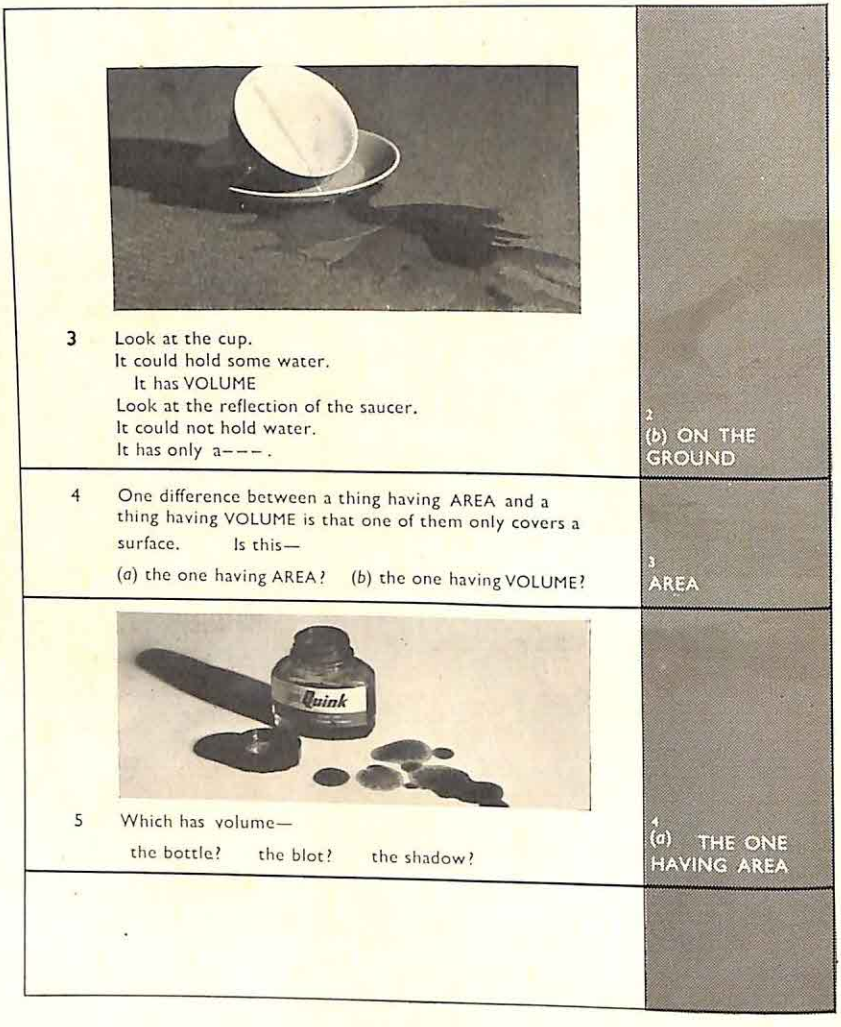
111 Now try these equations, *without looking at Panel J or at your previous solution:*

$$2x + y = 6$$
$$3x + 2y = 11$$

Note the close similarity of these examples to that in the panel. The reader may object that I am inviting him to teach solutions to every conceivable form of simultaneous equations. This is not in fact the case. The programme must now go on to wean the student until he can cope with every situation, but this must be done by very gradually withdrawing support. At every step we must elicit understanding of why certain actions must be performed, and our efforts to do this should be tempered by the

12. *An Early Programmed Reading Room*

This room, at South Wigston Junior School in Leicestershire, shows the children using tapes and proboxes in the remedial situation. The taped material is played from a central tape recorder and matches tasks prepared beforehand by the teacher.



3 Look at the cup. It could hold some water. It has VOLUME Look at the reflection of the saucer. It could not hold water. It has only a– – –.	2 (*b*) ON THE GROUND
4 One difference between a thing having AREA and a thing having VOLUME is that one of them only covers a surface. Is this— (*a*) the one having AREA? (*b*) the one having VOLUME?	3 AREA
5 Which has volume— the bottle? the blot? the shadow?	4 (*a*) THE ONE HAVING AREA

13. A page (reduced—the actual page size is $8\frac{1}{4} \times 6\frac{1}{2}$ in.) from DISCOVERY PROGRAMMES, *Area and Volume* by John Leedham and D. V. Parker. (See also pp. 41–2.)

The response column in the book proper is a tint of the second colour used, so that the answers are not too conspicuous against the pale background.

necessity to build up the student's confidence both in himself and in the programme.

One point is so important that it deserves re-emphasis. Examples, especially of a problem, are seen in two very different ways by a teacher and by an average pupil. Every effort must be made to bring pupils to the stage where a problem is viewed as an entity. This process is made more difficult because of the sophisticated style used by many authors and examining boards, in an endeavour to make their examples appear *elegant*. It is a sad fact that many students are handicapped not so much by the intrinsic difficulty of the mathematics, or physics, or whatever it may be; but rather by the involved wording in which problems are couched.

Accepting that training needs to be given in reading problems and deciding what is wanted, programmed learning is in a position to give much needed practice in acquiring this art. Do not despise the elementary question aimed at extracting simple information from printed matter. It is infuriating when a pupil can solve 'pure' examples with 100 per cent success, but is completely incapable of transferring this skill to cases where the example is dressed up as a problem. It must be appreciated that there is here a skill to be learned, and a programme is a useful way of doing it.

There are many styles and presentation forms for construction of programmes in mathematical subjects. The reader can do no better than obtain a variety of published programmes, and work through them noting down any techniques which appeal to him. A bibliography of such programmes is given at the end of this book.

There is vast scope for individual writing of programmes in this field, and there is probably no area of study where more fruitful results can be obtained. As a final plea the author would ask teachers to be inventive. Do not slavishly adopt other people's methods. You may well devise better ones of your own.

13

Programmed learning in practice, now and in the future

An optimist might suppose that having gone through the labour of writing and validating a programme, all would then be plain sailing. Similarly, the man who buys a set of commercial programmes perhaps thinks his teaching troubles are over. Although there is some truth in such attitudes, the use of programmed learning inevitably brings certain practical administrative problems.

In the nature of most programmes each pupil works at his own pace. Unless a class is unusually homogeneous the effect of this is to spread individuals out along a spectrum of progress. This is particularly true when using longer programmes: a bright student may be on Frame 300 at the same time as one of his less able fellows has only reached Frame 150. Unless some provision is made, any time saved by using the programme is likely to be wasted; the fast worker will be unoccupied when he finished the sequences, and after a few experiences of this nature he may downgrade his speed to avoid the hiatus.

How do we cater for these able students? We must find some means of capitalising on the time they save by use of the programmed medium. Solutions to this problem will be particular to the subject matter and the views of the teacher concerned. Some methods which have been utilised are:

(*a*) *Science subjects.* Pupils finishing the programme are instructed to perform experiments additional to those usually done.
(*b*) *Mathematics.* Pupils are given a number of more sophisticated examples to work.
(*c*) *Languages.* Foreign newspapers or periodicals can be supplied.
(*d*) *Any subject.* Appropriate library books can be made available.
(*e*) *Any subject.* A programme on some topic not generally covered is given out.

Alternative (*e*) is an idealised solution, and such programmes are not generally available. In any case, some of the other suggestions may be equally or indeed more valuable. Teachers will be able to extend this list greatly within their own subject. The vital thing is that there should be some interesting activity ready for early finishers. Never devise some aversive task for this purpose, or your pupils will gradually reduce their rate of working so as to avoid the task.

A programme is a systematic form of study, and it behoves the teacher using programmes to adopt a systematic attitude to their use. No other medium involves such a vast quantity of written student responses, and it is desirable to organise these carefully. Ensure that all answers are written down, *in ink*, in a special exercise book. If ink is used, coupled with a firm instruction that nothing written is to be obliterated but only struck through, the exercise books will provide an invaluable guide to the effectiveness of the programme and to the student's progress. This procedure will also play some part in discouraging the boy or girl who is predisposed to quick but careless answering.

For your own part, keep a careful record of:

(*a*) The frame number reached by each pupil at the end of the week (or some other convenient time interval).
(*b*) Scores in each test that is included in the programme, with the date when the test was taken.
(*c*) Frames answered incorrectly. Pupils can be asked to

regularly submit a list of such errors; they will be conscientious about this if you adopt a neutral or sympathetic attitude, throwing any blame on to the programme.

Such information as this is vital for a continual survey of the programme. Although considerable validation may have taken place previously, there will almost certainly continue to be room for detailed improvements. In any case, a new class may be lacking in certain information or abilities which were possessed by your validation pupils. When your records reveal this state of affairs you can take appropriate action, such as interposing a remedial conventional lesson, or providing a written aide.

When using published programmes one should still work along the same lines. There is nothing sacrosanct about published material; it may be laborious to go through a book writing in variations, or sticking in short sequences of your own, but the labour will be much less than that of writing your own programme from scratch. And teachers are fortunate in having a vast source of voluntary workers at their disposal.

The costs of typing and duplicating are so high that it is often justifiable on economic grounds to buy a programme even when only part of it is suitable. The question whether or not to obtain commercial programmes has been argued a great deal by the pundits, largely in a vacuum, since so few programmes are at present on sale. Several bodies have produced exhaustive lists of criteria for assessing programmes, and publishers are sternly commanded to provide complete test data for each programme—a sort of 'Good Housekeeping' seal.

The reasoning behind much of this argument and discussion may well be faulty and inspired by grossly inadequate knowledge of both programmed learning and the practical teaching situation. Consider some of the variables involved: let us suppose a publisher issues a programme validation-manual which includes:

1. The programme post-test.
2. The age, average I.Q., etc., of the pupils used in the trials.
3. The statement that using the final draft, 90 per cent of

pupils achieved a 90 per cent score in the post-test (the so-called 90/90 criterion).

4. The average time for completion.

No doubt other information will be given, but these four items will suffice for our purposes. Now first a prospective client has to judge whether the post-test adequately examines all the knowledge supposedly taught by the programme. This cannot be done by merely comparing the stated aims of the programme with the post-test: the programme must be carefully read to see whether it goes beyond the stated aims, thus rendering the post-test inadequate. This may not matter, except that more time will have been taken than was necessary, so now the stated time-figures, adjusted for age and I.Q. of the validation students, must be examined. Is such a time commensurate with the importance of the subject?

A final question which needs to be asked is, 'Who marked the post-test scripts, and on what basis were the marks allotted?' Every teacher knows that examination marks vary enormously, both according to the marking schedule drawn up and according to how an individual examiner interprets the schedule. A set of test results can mean anything or nothing, depending on these factors. In any case we are frequently more interested in the ability of pupils to *retain* information and to *transfer* it to other situations. It is most unlikely that any publisher can give much in the way of a guarantee in this respect.

If, then, a programme has to be bought without much value being placed on specification material, what procedure should a teacher adopt? A common-sense suggestion can be made here. If the subject matter seems suitable, write off for an inspection copy: when it arrives, look through and check that it is factually correct and that the treatment does not clash with your own notions. If you are satisfied, obtain a volunteer typical of the class you have in mind and put him to work on the programme. You will in this way quickly obtain a good indication of the programme's value. If two or more volunteers can be found, so much the better. You will also be able, if you wish, to devise your own *retention* and *transfer* tests, and thus ensure that you have a legitimate use for the programme in question. When you have completed your investigations a set of the programmes can be bought in the reasonable expectation that they will be valuable; alternatively, the inspection copy can be returned with a polite note of thanks.

A process such as that just outlined sounds laborious—this is not the way textbooks are usually bought. But by following such a plan you will get only what you want: the effort involved pays very handsome dividends. School stock rooms not infrequently hold many sets of largely pristine textbooks—books bought as a result of reading publishers' advertisements combined with a hasty inspection of a copy, which turned out to be largely inadequate in practice.

Future prospects

It can fairly be said that the importance of programmed learning lies less in the method itself than in the outlook of mind which it represents. A programme is essentially a pupil-centred medium of instruction: every care is taken to ensure that the material is suited to the ability and maturity of intended recipients.

It may be argued that most forms of instruction follow this principle, or at least that this can be the case if preparation is conscientiously carried out. Such an argument misses the main point: a programme is (or should be) produced and tested in a reasonably scientific manner. We do not rely on vague intuition when constructing programmes, instead they are validated by the best judges of all—the pupils who are to learn from them. This instructional rationale, i.e. rigorously basing the material on feedback from students, will, we may expect, spread from programming to other learning media.

This is in essence what should be meant by talk of 'programming' TV courses, or slide/film lessons, or taped lessons. It is not sufficient for a course to be meticulously planned; 'programming' surely implies a series of revisions on the basis of feedback. We may reasonably hope that when this genuine programmed approach is adopted in the construction of all teaching media we shall have at our disposal far more powerful tools for teaching than are available at present.

With a presumed spread of programming techniques to TV, tape, etc., what is the future of 'conventional' programmed learning, via teaching machines or programmed texts? There will surely always be a vital place in the school curriculum for pen and paper work, and it is unlikely that programmes, as at present constituted, will disappear. What is much more likely is that we shall see the development of an integrated course of study in which all available methods will be utilised to the full. One would expect to see TV, film, tape, programmes, textbooks, lecture discussion and so on all playing their part.

It cannot be long before the novelty of programmed learning has disappeared for most teachers. This does not mean that the majority of teachers will soon be adopting programmes in their courses, but rather that most of the profession will at least be aware of the existence of the method. It is to be hoped that no one will prejudge programmes without practical experience of their effectiveness. Eventually we shall perhaps reach the stage where the novelty ceases to exist for pupils. This point is unlikely to be reached for many years in some cases, and the situation will probably arise where in some schools programming is non-existent while at the same time other schools will be employing the most up-to-date media on a wide scale. Such divergences have always existed in British schools, and will presumably continue to do so.

The question is frequently asked, 'Do we need new instructional media, or are we merely introducing change for its own sake?' Thinking of this type shows a completely introspective point of view. The world is changing at an accelerating pace, and for education to remain static is a contradiction in terms. The impact of science and technology, and of more liberal thinking, has touched every aspect of our life. Luddites will no more succeed in halting progress in education than their predecessors did in industry. Anyone with some familiarity with the results being at present produced by ten or more years of schooling can only conclude that for many children almost any change must be for the better.

Assuming, then, that programmed learning is here to stay, is it likely to develop much over the years? Research is being conducted into methods of programme construction, and we can look forward to a rapid increase in our knowledge of the variables involved. Large sums of money will be needed to turn theory into practice, but there is ample evidence showing a greater public interest in education than hitherto. When people become as concerned about the conditions under which children are taught as they are about the progress of our motorway system, when in other words we begin to establish a proper order of priorities, then we may start to do as well for our pupils as is undoubtedly possible. This time may now not be far off.

Once more we come back to the role of the teacher. Will the advent of fully programmed courses diminish the importance of the profession? The answer is that the teachers' work will quite possibly become more intensive, but at the same time less trivial. Only the teacher can know what is best for the individual pupil, and the time is coming where each of a teacher's charges will have his course of study individually tailored to his needs. The teacher will, according to his expert knowledge, decide what media, at what time, are most suitable. Naturally he will constantly review progress and adjust accordingly. Such a task is obviously a radical departure from the present situation, but we can expect the change to be gradual, and we can be sure that by making use of modern methods of management a systematic approach can be devised.

Equally we can hope to see the teacher coming into his own in the role of demonstrator and expositor *par excellence*. Lessons conducted by the teacher will no longer warrant the dubious adjective 'conventional'. When the class meets formally for teacher instruction this will no longer be a matter of routine. In such an atmosphere (and of course having much more time for preparation) any teacher will be able to rise to the occasion, and fire his pupils with enthusiasm in a way seldom achieved today.

Such group occasions apart, teachers will be spending a good deal of time in discussion and 'teaching' with individual students during the programmed work. One cannot fail to think that the profession will enjoy a much more dignified and enhanced status, when the full force of modern techniques is finally brought to bear on the supremely important task of making the teacher's work richer and more efficient.

PART FOUR

Looking ahead

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14

Research results

At various institutions in this country research has been proceeding for many years into numerous educational topics. Except perhaps in the field of testing, much of this work goes unnoticed by the practising teacher, and indeed one might be forgiven for dismissing much educational research as irrelevant to everyday classroom conditions.

With the appearance of new instructional media—programmed learning, TV, film projectors and so on—we might expect research workers to contribute a great deal more to the teaching situation. This has in fact been the case, particularly in the U.S.A. In this chapter we shall discuss some of the experiments conducted into programmed learning.

In constructing a programme one may hopefully turn to the research workers for information anticipating that various guidelines will have emerged to assist the author. Unfortunately such hopes are largely illusory. Enormous numbers of experiments have been performed with the aim of establishing the 'best' method of programming, and these experiments have generally failed to reach any firm conclusions.

For example, it should be easy to discover whether *multiple-choice* responses are superior to the *constructed-response* type, but results generally show there to be no difference. There are some indications that the first of these modes is better for teaching *recognition* and the second for teaching *recall*, but the evidence is hardly conclusive. Again, should the student write down his responses or merely 'think' them? Research suggests there is no difference except that writing takes more time.

It is not improbable that the null results obtained in so many comparative experiments occur because the programmes used were very short. It seems most unlikely that useful information can be gleaned from a procedure where students spend less than an hour working through thirty or forty frames. In the remainder of this chapter we will try to pick a path through the morass of research results, rather with the aim of seeing what is not known than in the hope of obtaining definite guidance.

Linear v. *branching programmes*

In the past a number of investigations were conducted comparing these two methods of programming. No clear advantage has been found in favour of either mode. The idea of two schools of programmers, the 'linear school' and the 'branching school', has now tended to disappear, and the pragmatic view is widely taken that one should use linear and branching methods as and where appropriate. For example, in writing a basically linear programme the writer may encounter an area of learning where a common error occurs. Rather than attempt to circumvent this error by rewriting the linear programme, it may be more effective to introduce a short branch of remedial work.

A practical illustration of this can be taken from Physics. Consider the problem: 'A body has initial velocity 4 ft/sec and 3 seconds later its velocity is 20 ft/sec. Find the average velocity of the body during that time.' (*Uniform acceleration assumed.*)

The correct procedure here is similar to finding any sort of average:

$$\text{average velocity} = \frac{4 + 20}{2} = 12 \text{ ft/sec}$$

but a not uncommon error is to divide not by 2 but by the given time, i.e., in this case

$$\text{average velocity} = \frac{4 + 20}{3} = 8 \text{ ft/sec}$$

Now it may well be possible to forestall this mistake by a suitable series of frames, but possibly a quicker and surer method will be to allow the error to be made, then direct those making it to a remedial frame or sequence. Precisely where to introduce branches of this sort must be decided by each programmer in the light of his own and his students' experiences, but in any case, as is pleaded elsewhere, variety is worth having for its own sake in that programmes have a tendency to become boring, and any method of alleviating this should be adopted.

One common criticism of linear programmes is that they are generally written and revised with the weaker pupil in mind, the result of this being that the less weak are made to work through a lot of unnecessary material. There is some truth in this, but the difficulty can be avoided by the technique of 'skipping'. In this process a student achieving a certain criterion is instructed to miss out a frame or frames. The criterion can be put in several ways, for example:

If you got the last three frames correct, move straight on to Frame 72.

69 Solve $2x + 5 = 9$.

In this case the programme is giving practice at solving simple equations, and the programmer considers that any pupil who has obtained correct answers to the first three need not practise further. Frame 72 will be the start of some new material.

In one sense, skipping represents an attempt to incorporate several different difficulty levels in the same programme. Such a programme can be used for a wider range of abilities without danger of excessive boredom or difficulty for able and less able pupils.

Response mode

Virtually all programmes so far written use either the *Multiple Choice* (MC) or the *Constructed Response* (CR) mode. As previously stated, there is little to choose between them from the point of view of learning efficiency. A criticism of the MC mode is that your alternative answers must be plausible, otherwise the correct response is obvious, and equally it is a bad thing to present students with plausible wrong answers. In addition to this there is in the United Kingdom a genuine reluctance among teachers to ask pupils to select answers from a list.

A method is available which avoids the above difficulties, generally referred to as the *Constructed Choice* (CC) mode. As the name suggests, this is a combination of MC and CR; the frame appears to be of the usual CR type and the pupil composes his answer. However, when he looks for the correct response he is confronted with a list of alternatives, e.g.:

---

124 The French for 'the door' is -- -----.

124a (*a*) le porte (*b*) la porte (*c*) la port (*d*) any other.

According to the selection made in 124a, the student will be instructed to proceed to new material, or to a remedial sequence.

Once again, the dictates of variety call for occasional use of different modes, no matter what the programmer's own preference may be. A problem to be decided, in particular with CR frames, is whether or not responses must be written. Many experienced programmers when working through a programme (with the aim of learning the material) do not write their answers, they merely 'think' them. This in spite of the usual strict instructions to write down every answer. Naturally this has attracted the attention of research workers and comparisons have been made between the *overt* (written) and *covert* (thought only) modes. Results are conflicting, but in general it seems there is little difference in learning, and obviously saving of time results from using the covert mode. The relative merits of these modes probably depend on a number of factors such as subject matter, ability and personality of individual pupils, etc., and every teacher will have to make up his own mind about this.

A further refinement which has received attention is the so-called 'reading' mode. In this case, the responses are actually filled in already—perhaps in red, perhaps in capital letters. The pupil just reads his way through. Surprisingly enough this process appears to work as well as any other method, a result which strongly suggests that the success of programming lies in care of preparation of the programme, rather than in any particular methodology. None the less, both the reading mode and the covert mode should be regarded with great caution by the school teacher. Neither of them provides the degree of control that is present when pupils have repeatedly to commit pencil to paper. Anyone experimenting with these more passive modes will do well to include at regular intervals short tests which have to be shown. Lacking some such check, there may well be some students who traverse whole programmes without concentrating.

It should be remembered that the research situation is vitally different from the usual classroom one. Anyone who is conscious that he is taking part in an investigation is likely to be highly interested. Would that our pupils were always in such a state.

Machine or text?

Such publicity as programming obtains in the popular press tends to be concentrated on teaching machines. This is inevitable, but must be regretted because the machinery plays a very minor role in the teaching process. There may be available in the future computer-based teaching machines *which do in fact teach*, but at the moment the machines are merely vehicles for presenting a programme. One question which we must investigate is, 'Is a programme likely to be more successful when presented via a machine, rather than as a programmed text?' The answer to this is an unequivocal 'No'.

Many investigators have compared machines and texts, and there can be no doubt that for most purposes the machine is superfluous. One exception occurs in the validation of programmes, and this is discussed elsewhere. Again there may be cogent reasons for using machines with young children or with handicapped and retarded children; in such cases the novelty value of the machine may provide valuable motivation.

It should be noted that if machines are used they have to be stored, got out, put away, kept in repair, and, worst of all, the programme has to be frequently loaded and unloaded. Virtually every tyro programmer designs and constructs his own teaching machine at some stage. It would be well if these amateur designers take into account that they (or their pupils) will have to load thirty odd programmes into the machine at the start of the lesson, perhaps turning each programme to a different place; at the end of the lesson each programme has to be removed and programmes and machines cleared away. Such a daunting prospect must surely bring home the difficulties inseparable from the use of simple machines on anything like a large scale.

Group work

One of the advantages usually claimed for programmed learning is that pupils learn individually rather than as part of a large class. It is obviously true that a pupil gains by having, as it were, his own private tutor, and this aspect of programmed learning has been explored in Chapter 9. But are there any positive disadvantages in individual tuition? One such disadvantage is the ignoring of sociological factors in education—a pupil learns from his fellows as well as from his teacher. There is much to be gained by discussion of difficult points with someone else who is in the same, or a similar, boat. This sort of argument has led some workers to investigate the use of programmed learning for teaching students in groups rather than as individuals. A less-ambitious approach is where pupils work in pairs, the partners moving at a constant rate. Whenever either pupil makes a mistake, or becomes stuck, discussion takes place, and the pair proceeds only when the difficulty is removed. It has been claimed that this method produces better retention of material than is obtained by individual use of programmes.

Programmes v. *conventional teaching*

This thorny question has been left until last, not because it is unimportant but because it is largely irrelevant. No one seeks to compare teachers with film strip projectors; we consider the projector to be a useful aid for the teacher, so is a programme. This has not always been appreciated, and many comparative experiments have been conducted. As was inevitable, results were useless. After all, what sort of teacher (good, bad, average) are you comparing with what sort of programme (good, bad, average)? What about the novelty value of the programme? And so on.

However, as outlined in Chapter 15, the point of view most generally accepted now is that programmes are ancillary to teachers, and abundant evidence exists to show their value for this purpose. This is a vitally important point; programmes must be seen as a means of improving instruction, not as a substitute for a teacher. The exception to this is where suitable teaching staff are not available.

The future

Research into programmed learning and other teaching methods is proceeding on a large scale, particularly in the U.S.A. Teacher programmers will do well to keep abreast of current work, and this can best be done by subscribing to an appropriate journal. Two such are: *Programmed Learning*, published by Sweet and Maxwell for the Association for Programmed Learning, and *New Education*.

15

Design for a new school

James McClellan, writing on the subject of Programmed Instruction and Philosophy of Education (*Prospectives in Programming*, Macmillan, N.Y. 1963), writes as follows:

The role of the school

> The second question that philosophers of education have traditionally dealt with has been that of the purposes for which we have school, or the purposes which schools ought to serve. Programmed instruction complicates the question in the following way: The more we consider the over-all implications of automated instruction, the less likely it appears that our schools as now constituted will have a very significant role to play in education. The practice of herding together children in groups of 25 or more; placing them in buildings which are made up of large modular boxes; forcing them for the better part of a day to listen to an adult and perform meaningless tasks with pencil and paper—all these practices have been regarded as objectionable in themselves; but up to the present there has been little chance of getting rid of them, simply because there was no other way to raise a large enough number of people to the minimum degree of literacy required for the on-going of our particular social order.
>
> The practices of our conventional school are objectionable on two grounds. First, they are inefficient in accomplishing the goals for which they were established. It simply should not take so much time, energy, money and adult brain power to effect the rather minor kinds of behavioural changes that we

have seen actually accomplished in most schools. Second, schools find it impossible to operate except as instruments of aversive social control, and as our moral consciences become more refined, we find any institution so constituted objectionable on moral grounds. As compared with normal classroom teaching programmed instruction should be both more efficient and humane.

The availability of programmed material provides the opportunity to consider the division of school time into learning periods based on the individual, small groups, class-sized groups, larger groupings. In order to put the position clearly use will again be made of a typical example. The following proposals relate to plans at present in hand for building, staffing and planning a new type of school.

However good the organisation, however successful the programme or reliable the machine, any school situation will stand or fall by the successful interrelation of its human parts. The following plan attempts to consider the allocation of time and teacher in a school designed and thought of to be inspiring and humane.

Outline proposals for school accommodation for 400 children of the age ranges seven plus

These proposals are made on the following premises:

1. That administrative groups within the school will not exceed twenty-four.
2. That the customary learning group will be eight or less.
3. That there is free access to individual learning situations.
4. That the aim will be the self-directing small group.

Twenty-four pupils is a good rational figure; it fractionises and builds up to larger groups adequately. It may be argued that this is an impossible staffing ratio, and the forecasts are that the staffing position will deteriorate. Nevertheless, with clearly stated aim and a building designed to accommodate the necessary aids, it should be possible to maintain the groupings in the adverse situation which obtains at present, or even in a worsening situation.

First then, as to organisation. One should be able to anticipate that the teacher–child ratio should not be in excess of 1 : 40. We are thus faced with sixteen children 'over' for each teacher, and my proposals are meant to deal with this situation.

PRIMARY REQUIREMENTS

1. Adequate social areas for movement, dining and so on, which are customary and about which only minor modifications need discussing.

2. Library/retrieval area. This is a customary library, designed also to house material which is organised on a planned basis for lesson support. It would need to be staffed by a laboratory assistant. This title is given to avoid difficulty about ancillary staff.

In this area will need to be housed:

(*a*) The linear programmes in booklet form with their supporting kits.
(*b*) The portable devices such as battery-operated tape recorders.
(*c*) Master circuits for B.B.C. programmes.
(*d*) Master circuits for self-produced material, both sound and vision.
(*e*) A systematic organisation for recording children's progress without fuss.

3. Working areas. Young children need to recognise their own area and for large parts of the time to function from it. It seems to me that a vertical arrangement covering four years of school life has much against it, but a vertical arrangement covering two years of school life has a good many benefits. I thus envisage a rough division of the areas into younger/older, each accommodating 192 children. This would give roughly eight administrative groups in each half and five or six teacher groups in each half. The allocation of the working space would be on the basis of forty spaces to each teacher, and of this space one-third would be designed for self-instructional work. In this area would be focused individual learning devices and programmes drawn from the library together with the group consoles, which would also incorporate the TV. Each of these rooms should be linked into the retrieval area, which would be capable of diffusing (*a*) instructional TV and radio, and (*b*) programmed material, both sound and vision.

It may be that the cost of centralising is a good deal more than the cost of maintaining separate units. But if a saving of teaching strength is to be achieved the reliable and centralised production of this sort of material is essential. To this end each group of three teachers would have a further laboratory assistant for the maintenance of their material.

We should fairly often need to group together 100 children of an age range, 40 children of a teacher group, 24 children of administrative groups, and the space openings and closings ought to permit all these. The children would often be in the individual and small group learning situation, which also needs providing for.

One has now to consider the actual procedures. It is quite easy to suggest that children will avail themselves of programmed film strips and recourse materials in the absence of a teacher. It is quite another thing to ensure that this is so. The plan set out below indicates the possibilities for school groupings.

From the classrooms, space is borrowed in order to ensure that a learning area is available to children on an individual or small group basis. Within the classroom will exist points for audio and visual reproduction of material spread from the control room. This control room will receive and disseminate broadcasts from outside and from inside the school. Any classroom will, in its turn, be capable of transmitting TV or sound throughout the system. The same facility will exist in the main area for learning, where the study carrels and group consoles will be lodged. These will be explained below. The control room will also house portable tape recorders. Programmed booklets will be in the traditional library. Some system of recording progress will need to be evolved, and this will be required to tally with the teacher's record of progress. It is important that if the work is to be worth while these records should be maintained methodically without intrusion upon the teacher. It is his job to examine these records of progress and spend his time with the child, not with paper and pencil.

The plan most likely to be adopted would be one based on the class unit record, where each child's name would be associated with a member of staff. The daily records of attendance, dinner money, milk and so on would need to be planned so that the control room would become the office of the school secretary and an assistant who would be capable of modest technical adjustment and repair.

It is anticipated that in the early stages the children will start from a traditional class identification, but that almost at once twelve of the children or more to represent a third of the class will seek the help of the learning situation. Let us trace the possible progress of a child aged eleven, of average ability and with experience of programme work, who arrives at our New School.

It would be a first-class idea if he could have started off at 8.45 with his own session of P.E. in the outdoor pursuit area or in the swimming bath. He could only do this after ensuring that his records were in order, which might mean recording at his desk space his presence and dinner and milk requirement and taking any money to the bank desk, where he puts it into a named cash box which goes into the self-depositing safe for the secretary to deal with later. If many children are bringing money at one time the cash boxes are made up in the classroom. The question of wrong money, no change and so on will work itself out in a good school atmosphere. Where this does not happen there will already have been plenty of experience how to put things right.

Our pupil, if he were scheduled for a class lesson, would join his twenty-odd fellows with the teacher in the customary room at 9.30 a.m. Lateness would mean whatever the teacher thought appropriate; continued lateness could soon be adjusted. The class lesson would carry on with whatever the teacher felt to be necessary until perhaps 10.45 a.m. After break our young scholar would now take himself to a study carrel. It might be that he had undertaken to learn about the sky at night, in which case he would be using a prepared booklet with matching season slides and the 8-mm concept film. These would be available in one position, and from eleven until twelve he and four or five others would be progressing individually. Where dual use of apparatus arose, experience suggests that little time is wasted save by the very quick child.

In the afternoon he may well be required for the first twenty minutes to use one of the specific remedial programmes in Number or English and to take the results to his teacher. For the rest of the day he would be employed in the creative pursuits that belong to Junior School life, only under more flexible conditions. Art, Pottery, Music and Games ought to be achieved under small group conditions related to the interests and special abilities of the various teachers. It may well be that during this time larger-scale groupings will come about. The use of the school's close-circuit television for broadcasts of specific content may have useful application for the whole of an age group. It certainly appears to be more convenient to handle movement in pliable numbers. Throughout the day's work the idea ought to grow that the work has an aim, a steady purpose and a worthwhile result. Much of it ought to be the result of individual achievement and almost as much the result of cooperative ventures. The real difficulty will lie in the speed of progress, if our present experiences can be relied upon. This means that the work will need to be constantly revised and extended.

Teacher time for preparation is an essential requirement. It is obvious that the teacher aide or auxiliary to look after equipment, books and so on is going to be very necessary. Besides the one working in the control room there would need to be two more on material control in the prepared learning areas. Since we face an impossible position from the point of view of teacher shortage, the profession must recognise that it stands to enhance its prestige by using the same sort of aides as do the medical and legal professions. If we are content to let the next decade submerge us with children and half-achieved work, rather than employ the results which brains and diligence have suggested for us, it will be a thousand pities.

The role of the teacher in the new school is that already envisaged in such things as the integrated day or the various methods of activity. The difference will arise in the much more deliberate preparation of material and knowledge of the child's progress. The situation will arise where the teacher will less and less blame the child for inattention and look more and more critically at the material which is being offered and the methods being employed. Since the load will be designed to be less on the teacher, he will at last stand the chance of being able to do his proper job. He will be able to nurture, to be considerate; in short to give a child some time. This will not be achieved merely by hoping for it; every gain comes as the result of effort.

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